ANALYSIS OF SOUTH AFRICAN RUGBY COACHES' ENGAGEMENT WITH PERFORMANCE ANALYSIS

BY

Zukhanye Magwa

Thesis presented in fulfilment of the requirements for the degree
Master of Science in Sport Science
in the Faculty of Education at
Stellenbosch University

Supervisor: Prof E. Terblanche
Co-supervisor: Mr. W.J. Kraak

December 2015

DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: December 2015

SUMMARY

The analysis of sport performance has been noted as one of the key building blocks within the coaching process, whereby coaches evaluate a player's performance, identify weak points and provide adequate feedback to correct or improve future performances (Groom *et al*., 2011). The introduction of performance analysis (PA) has allowed coaches to have a wider range of tools available to provide feedback. In sports such as rugby, analysis has been a key tool in monitoring the demands of a match as well as playing a part in a players' decision making during a game (James, 2009). Traditionally, the assessment of performance was linked to a coach's observational capacity which could be influenced by their subjective views. Furthermore, research has shown that coaches were able to remember less than 50% of key events during one half of a soccer match. Thus indicating that coaches' capacity to observe, recall, feedback and provide an accurate analysis of key events during a performance could be limited.

The primary aim of the study was to use an online survey to evaluate how performance analysis is used by rugby coaches at a sub-elite level in South Africa. The main objectives included determining how PA contributes to the coaching practice and its use amongst different levels of rugby (provincial, university, school) in South Africa. In addition, the secondary aims were to assess the extent to which PA information was integrated into coaching practice, how coaches valued the use of PA and the role of the performance analyst in the coaching process. The study followed a descriptive design where data collection was conducted using an electronic questionnaire consisting of both open-ended and closed-ended questions. A total of 46 South African rugby coaches from provincial (n = 15), university (n = 15) and school (n = 16) volunteered to take part in the study.

The key themes that were investigated included: demographic information of the coach, the analysis process, feedback to the players, the implications for coaching practice, how he interacts with the players, factors that influence the coach's selection of specific key performance indicators and the coach's assessment of the

value of PA. The coaches were provided with a glossary of terms used in PA to assist them with completing the survey.

Most of the coaches (67.4%) had access to video footage after every match, while 21.7% of the coaches rarely had access to video footage. Provincial coaches (93.0%) had most readily access to video footage compared to other coaching levels ($p = 0.004$). The majority of coaches (80.4%) received video footage within two days after a match. Provincial coaches had the fastest delivery time, with most of these coaches receiving video footage within a day (87%).

Most of the coaches carried out PA themselves (67.4%). The majority of coaches (60.9%) identified PA to inform their coaching practice all the time. This was the same at each respective level with more provincial coaches using PA to inform their coaching compared to other coaching levels (86.0% at provincial, 40.0% at university and 56.0% at school). Most of the coaches (84.8%) in the study acknowledged that the use of PA to introduce changes to their game tactics was essential and very important. Most of the coaches (63.0%) also highlighted that their coaching philosophy was the main influence on their selection of KPIs with the selection of KPIs changing from game to game, apart from most provincial coaches who's KPIs remained consistent from game to game (47.0%). There were 47.8% of the coaches who found the service provided by the individual who conducts PA as essential, while 34.8% valued it as important.

It was concluded that most coaches involved in high level coaching in South Africa valued the use of PA and used it consistently to inform their coaching practice. The coaches involved at the highest level of coaching in the study, namely provincial coaches, have the most access to PA and used it more consistently to guide their coaching practice.

The findings of this study have provided insight to how and why South African rugby coaches engage with performance analysis. In particular, these findings inform specifically on how performance analysis currently impacts their coaching practice.

OPSOMMING

Die ontleding van sportprestasie is bekend as een van die belangrikste boustene binne die afrigtingsproses, waardeur die afrigters 'n speler se prestasie evalueer, sy swakpunte identifiseer en terugvoering gee hoe om toekomstige prestasie te verbeter (Groom et al., 2011). Die bekendstelling van prestasie-ontleding (PO) het afrigters toegelaat om 'n groter verskeidenheid gereedskap te gebruik om beter terugvoering te gee. In sportsoorte soos rugby speel ontleding 'n belangrike rol in die monitering van die eise in 'n wedstryd, asook 'n speler se besluitneming tydens 'n wedstryd (James, 2009). Tradisioneel was die assessering van prestasie gekoppel aan die waarnemingsvaardighede van die afrigter, maar dit kan soms beïnvloed word deur subjektiewe denkwyse. Verder het navorsing getoon dat afrigters minder as 50% van die belangrikste gebeure in een helfte van 'n sokkerwedstryd kon onthou. Dus dui dit aan dat die afrigters se kapasiteit om waar te neem, te onthou, terugvoer te gee en 'n akkurate analise aan te bied beperk kan word tydens belangrike wedstryde of oefeninge.

Die primêre doel van die studie was om 'n aanlyn-opname te gebruik om te evalueer hoe Suid-Afrikaanse rugby-afrigters met PO betrokke raak. Die belangrikste doelwitte sluit in hoe PO bydra tot die sukses van 'n span en die gebruik van PO onder verskillende vlakke van rugby (provinsiale, universiteit, skool) in Suid-Afrika. Daarbenewens het die sekondêre doelstellings die mate waarin PO inligting geïntegreer word gedurende afrigting geëvalueer, hoeveel waarde afrigters aan PO heg en die rol van die prestasie ontleder in die afrigtingsproses. Die studie het 'n beskrywende ontwerp gebruik en data is ingesamel met behulp van 'n elektroniese vraelys wat bestaan het uit beide oop- en geslote-einde vrae. 'n Totaal van 46 Suid-Afrikaanse rugby-afrigters op provinsiale vlak (n = 15), universiteit (n = 15) en skole vlak (n = 16) het aangebied om aan hierdie studied deel te neem.

Die kern temas wat ondersoek was sluit in: die demografiese inligting van die afrigter, hulle ontledingsproses, terugvoering aan die spelers, die implikasies vir die

afrigtingspraktyk, hoe die afrigter in wisselwerking tree met die spelers, faktore wat die afrigter se keuse van spesifieke sleutel prestasie-aanwysers beïnvloed en die afrigter se assessering teenoor die waarde van PO. Die afrigters was voorsien met 'n woordelys van terme, wat gebruik word in PO, om hulle te help met die voltooiing van die opname.

Meeste van die afrigters (67.4%) het toegang gehad tot video opnames ná elke wedstryd, terwyl 21.7% van die afrigters selde toegang gehad het tot video opnames. Afrigters op provinsiale vlak (93.0%) het die meeste toegang gehad tot video opnames in vergelyking met ander afrigtings vlakke (P = 0.004). Die meerderheid van die afrigters (80.4%) ontvang video opnames binne twee dae ná 'n wedstryd. Provinsiale afrigters het die vinnigste leweringstyd, met meeste van die afrigters wat die video opnames binne 'n dag ontvang (87%).

Meeste van die afrigters het self PO uitgevoer (67.4%). Die meerderheid van die afrigters (60.9%) het PO gebruik om hul afrigtingspraktyk in te lig. Dit was dieselfde op elke onderskeie vlak, alhoewel meer provinsiale afrigters gebruik gemaak het van PO om hul afrigting in te lig in vergelyking met ander afrigting vlakke (86% op provinsiale, 40% op Universiteit en 56% by die skool). Die meerderheid van die afrigters (84.8%) in die studie het erken dat die gebruik van PO, om veranderinge aan hul speltaktiek voor te stel , noodsaaklik en baie belangrik was. Meeste van die afrigters (63%) het ook beklemtoon dat hul afrigtingsfilosofie die belangrikste invloed was op hul keuse van KPI met die keuse van die tipe KPI wat verander van wedstryd tot wedstry, in vergelyking met meeste van die provinsiale afrigters wie se KPI konsekwent gebly het van een wedstryd tot die volgende (47%). Daar was 47.8% van die afrigters wat die diens wat deur PO verrig word as noodsaaklik beskou het, terwyl 34.8% van die afrigters dit as belangrik gesien het.

Daar is tot die gevolgtrekking gekom dat meeste afrigters wat by hoë vlak afrigting in Suid-Afrika betrokke is, waarde heg aan die gebruik van PO en dit deurgaans gebruik om hul afrigtingspraktyk in te lig. Die afrigters betrokke op die hoogste vlak

van afrigting in die studie, naamlik provinsiale afrigters, het die meeste toegang tot PO en gebruik dit meer gereeld om hul afrigtingspraktyk te lei.

Die bevindinge van hierdie studie het insig verskaf hoe en hoekom Suid-Afrikaanse rugby-afrigters PO gebruik. In besonder verwys hierdie bevindinge spesifiek hoe prestasie-analise tans die afrigtingspraktyk van rugby afrigters beïnvloed.

ACKNOWLEDGEMENTS

I would like to show my appreciation to the following people who have made a contribution to my study:

Firstly, I would like to thank my family for always supporting me in every decision that I have made and for staying by my side through good times and always encouraging me to pick myself up through tough times. Thank you for always bringing laughter into everything we do.

To my mother, Nomhle Magwa, you have always been my rock and my pillar of strength in everything that I have done. You have always encouraged me to get an education and have supported me in everything that I do. You have also always encouraged me to work hard, reminded me to laugh and persevere through every task that I have taken on. To my baby sister Phethelo, you have always pushed me to work harder and I hope that I have set a good example for you to follow and surpass. To my older brother, I hope that I have made you proud and I thank you for always pushing me to new frontiers.

Prof Terblanche (supervisor), thank you for all your support, wisdom and guidance. I also would like to thank you for always motivating me during this journey. I would like to thank you for the sacrifices you made to help me succeed and for providing me with the opportunity to take on this challenge in my life.

Mr Wilbur Kraak (co-supervisor), thank you for your guidance in allowing me to see the bigger picture. Thank you for challenging me to be certain in the choices I make on and off the field.

Prof Martin Kidd, statistician at Stellenbosch University, thank you for your time and assistance.

Louise Engelbrecht, Sport Physiology Lab manager at Stellenbosch University, thank you for your willingness to assist, support and provide wisdom during my studies.

To my friends and colleagues, thank you for your support, advice and belief during my journey. It has been much appreciated.

The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

DEDICATIONS

This thesis is dedicated to my mother, Nomhle Victoria Magwa who has been my rock throughout my whole life. MamCirha, ulilitye lam lobombi. You have never doubted me and you have made a lot of sacrifices to provide me with the opportunites that I have as well as a good education. Ndibulela wena ngele thesis Ncibane, Khawuta, Nojaholo, Mhlantla, Nyembezana, Mhlathendlovu, uDlakalashe, Ntswentswe, Qhanqolo, Ntlokwenyani, Sihlobo SikaPhalo, Hloml'iphuthi lidala linempondo, MGcaleka.

TABLE OF CONTENTS

LIST OF FIGURES

Chapter Three

Chapter Five

LIST OF TABLES

GLOSSARY

Performance analysis

The collection of information from sport performances with the goal of developing an understanding of the sports to enhance future performances and decision making.

Performance analyst

The individual who may take record, analyse and provide feedback on selected key indicators on the coach's behalf.

Role of performance analysis

Allows analyst to evaluate, diagnose and provide feedback on information with the goal to enhance the athlete's performances in future.

Feedback

The process by which relevant information on sport performances is passed onto the players.

LIST OF ABBREVIATIONS

ELVs	Experimental law variations
IAAF	International Amateur Athletic Federation
IRB	International Rugby Board
KP	Knowledge of performance
KR	Knowledge of results
NOCs	National Olympic Committees
n	Total of completed online questionnaires
PA	Performance analysis
KPIs	Key performance indicators
PO	Prestasie-ontleding
RWC	Rugby World Cup
SARU	South African Rugby Union
UEFA	Union des Associations de Football
USSA	University Sports South Africa
VC	Varsity Cup
VS	Varsity Sports
WADA	World Anti-Doping Agency
WR	World Rugby

CHAPTER ONE

INTRODUCTION

Since rugby gained its professional status in 1995, teams have placed emphasis on finding new ways to improve player attributes and performance in order to gain a competitive advantage over their opponents (Duthie *et al*., 2003). Due to the law changes of the game and the ball being in play for longer (Kraak *et al*., 2011), there has been added pressure on coaches to provide their teams with a competitive advantage through novel training strategies. Some methods that have been used to improve player performance include testing the athletes' physical attributes (Duthie *et al*., 2003). This provides information to some extent on the demands that are required during a match (Green *et al*., 2011). However, this method generally lacks the ability to replicate the movement patterns experienced during a game. Another strategy is the utilization of technology, including among other, the detailed technical analysis of individual players, as well as team performances. The increase in the number of games being played over a calendar year has also been observed which means coaches need to prepare and monitor their players carefully throughout the season to minimize fatigue and injuries. Since teams, both within and between countries, may also play more often against each other and therefore become familiar with each other's tactics and game play, coaches also need to meticulously analyse opposition teams in order to adapt their own team's tactics and playing strategies.

Furthermore, it has been proposed that one of the main roles of a coach includes having the capacity to observe and assess performance (Wright *et al*., 2013). Research has shown that there are potential limitations in the coaches' capacity to observe, recall, provide feedback and give an accurate analysis of the key events of the game during live performances. It has been shown that coaches remember less than half of key events during matches (Wright *et al*., 2013). Therefore, purposeful performance analysis (PA) will enhance the coaches' observational and analysis strategies (Wright *et al*., 2013). PA allows coaches to monitor movement patterns, as well as the motor function of players (Green *et al*., 2011). It also provides rugby

coaches with a way to gain a competitive advantage over their opposition (Wright *et al*., 2012). It has been stated that the main aim of performance analysis is to aid the coaching staff as well as players in decision making by providing relevant information on performances (O'Donoghue, 2006). It can also be used to enhance the coaching staff's ability to identify and diagnose difficulties that the team may encounter during a game (Wright *et al*., 2012).

There has been a noticeable increase in the use of PA within professional soccer clubs over the last decade (Carling *et al.*, 2009). Blaze *et al.* (2004) reported that nine out of the ten English Premier League coaches who responded to a questionnaire used computerised notational analysis. This finding has been attributed to the increased accessibility of performance analysis tools, as well as the user friendliness of the latest software (Wright *et al*., 2012). Moreover, there has been an increase in the number of companies which provide a service to analyse games for the teams, following a game (Wright *et al*., 2012).

Although there has been research conducted on the reliability and game statistics of match and notational analysis, it is still unclear how this information is used by coaches (Groom *et al*., 2011; O'Donoghue, 2001; Wright *et al*., 2013). There is also limited information on the manner of how coaches may alter training sessions as a result of what has been observed during analysis (James, 2006). Evidence suggests that some coaches use PA as a reactive tool following a drop in performance or loss in form (Wright *et al*., 2012). Therefore, a starting point in research would involve how the coach utilizes information gained from PA to effectively recall, analyse and provide feedback to the team (Wright *et al.,* 2013). Furthermore, it may add value to study how the coaches utilize performance analysis as their approach towards it may be influenced by their previous experiences, values and beliefs (Wright *et al.,* 2012).

As stated earlier, despite there being limited research conducted on match and notational analysis, there is a lack of research in how coaches engage with performance analysis. There has also been minimal attention given at how notational analysis can improve performance, apart from a few attempts by some researchers (Jenkins *et al.*, 2007; Wright *et al*., 2013). Moreover, there are no previous studies in South Africa that have addressed this issue. Therefore, a clear gap exists between

research and coaching within this area of study. Thus, before one can make suggestions and conclusions on how PA influences performance, it would be appropriate to evaluate how coaches engage with PA and to see if it has played a role in contributing to a teams' success.

CHAPTER TWO

PROBLEM STATEMENT

1. INTRODUCTION

Although there has been a noticeable increase in the use of performance analysis in various sport over the past decade, there is still a lack of knowledge of how rugby coaches engage with performance analysis (Carling *et al.*, 2009; Groom *et al.,* 2011). In particular, this is the first empirical study in South Africa to describe the utilization of performance analysis in sub-elite rugby teams. Performance analysis has been shown to provide a link between a performance and other facets within sport science such as technical, physical as well as movement patterns deduced from biomechanical evaluation and the use of notational analysis. This allows coaching specialists to design specific training programmes to meet the team's requirements (Gabbett *et al.,* 2008). With professionalization, rugby coaches need to adapt to the constant changes made to the game. Lacking this quality can lead to a coach not being able to gain a competitive advantage over their opponents (Duthie *et al*., 2003; Green *et al*., 2011; Smart, 2011).

2. SUMMARY OF LITERATURE

The aim of this summary is to establish a theoretical background for this study by summarizing the literature on PA and coaching within rugby.

Since professionalization (1995), the science of analysing the game has rapidly developed to meet the changes in the demands of the game (Duthie *et al*., 2003). Research has shown that there have a been a number of advancements in the modern game, such as law changes, to make the game safer, improve player performance and promote game continuity. Some of these changes have also been introduced to meet the changes in the physical attributes of players (Fuller *et al.,* 2009). The changing profile in the game has also led to the introduction of PA. This process involves assessing the specific aspects of an individual or team's

performance in a competitive sport (O'Donoghue, 2006). This allows coaches to have a better understanding about various aspects of the game in order to improve future performances (Hughes & Bartlett, 2002). It also allows the coaching specialist to have objective views on team performances.

Research has shown that there has been an increase in the use of PA over the last decade, particularly in soccer (Carling *et al.,* 2009). This has been attributed, among others, to the increase in number of companies that provide this service. Furthermore, the role of a performance analyst has become more prominent in team coaching structures where they provide feedback to the coaching staff as well as the team (Wright *et al.,* 2013). Furthermore, with PA coaches have the means to provide objective feedback to the players about their performance (Carling *et al.,* 2009). It also allows the coaches to analyse the technical and tactical aspects of the team and make changes that will improve future performances (O'Donoghue, 2006).

However, from the literature reviewed, it is clear that the way in which rugby coaches engage with performance analysis needs to be analysed in order to assist the coaches and coaching specialists in understanding the use of PA in the modern game and how it potentially may influence the coaching process. Furthermore, it allows coaches to constantly evaluate their coaching philosophies as well as how they integrate the information that they receive from PA into their coaching practice.

3. AIM OF THE STUDY

The primary aim of this study was to examine how rugby coaches at a sub-elite level in South Africa use PA.

Objectives of the study

The specific objectives of this study were:

i. To compare the use of PA amongst three different levels of competition within South Africa, namely provincial, university and school rugby.
ii. To identify the extent to which the information obtained through performance analysis is integrated in coaching practice at the three different levels.

iii. To assess how the coaches value the use of PA as part of his/her coaching philosophy and success of his/her team

4. MOTIVATION FOR THE STUDY

Rugby is one of the most popular sports in South Africa and is contested over many levels. There is also a large financial investment into this sport with teams looking to attract the best rugby players gaining them a competitive advantage over their opponents. Some examples include the lucrative contracts offered to players with the aim of luring them away from their teams at club and provincial level. In addition, at school level bursaries are offered to young players to attract them to respective rugby playing schools. Furthermore, rugby unions in South Africa have become so competitive that they even offer players contracts while they are still at high school. An example includes a school player being offered a record breaking R350 000 a year contract by a large union to lure him away from his home province after he finishes school (Rugby 365, 2015). These financial investments have also helped teams expand their coaching staff, as well as introduce new technologies with the goal of contributing to a team's success. Some of these technologies include the use of PA.

Therefore, the analysis of South African rugby coaches' engagement with PA will provide insight on how important coaches regard this technology at the different levels of competition (i.e. provincial, university and school). It will also broaden coaches' perspectives on how PA can be used and what information they should get from such analysis. Furthermore, due to the level of play, higher level playing teams such as provincial teams (due to having more resources) may better utilize performance analysis tools, thereby contributing to their success. It will also provide insight at different levels of competition on how the data collected by PA influences the coaches' preparation for future performances as well as what factors influence the coaches' selection of key performance indicators (KPIs). Due to limited research on how coaches utilize performance analysis in rugby, it is important to expand the area of rugby coaching and PA.

CHAPTER THREE

LITERATURE REVIEW

1. INTRODUCTION

The professionalization of rugby union (hereafter referred to as rugby) in August 1995 has led to a number of changes both on and off the field (Mellalilieu *et al*., 2008). Most of these changes can be attributed to the ever increasing levels of competitions and growing sponsorships of teams and individuals. As a result teams place significant emphasis on finding novel ways to gain a competitive advantage over their opponents (Duthie *et al*., 2003; Green *et al*., 2011; Smart, 2011). It has also led to an exponential increase in rugby interest all over the world, which is particularly evident from the development of international club and provincial competitions in the southern hemisphere. An example is the Super Rugby tournament (Owen & Weatherston, 2002) which has grown from a competition involving 10 teams to the current 15 teams, as well as the increased popularity and performance levels of rugby in previously non-rugby playing countries. For example, the number of rugby players in the United States of America increased from 50 000 in 2004 to 1 130 000 in 2011 (USA Rugby, 2015). Furthermore, Africa has also seen significant growth in the sport with teams such as Kenya and Namibia being included in the South African domestic competition (Vodacom Cup). This is part of the South African Rugby Union's (SARU) mandate to help improve and develop the game in Africa with the aim of helping these teams qualify and perform at rugby World Cup tournaments. Moreover, the increased media coverage of international rugby has attracted widespread spectator support by showcasing more rugby games in the modern playing era. This has played a role in the subsequent financial investment into improving rugby as a sport (Owen & Weatherston, 2002). The rapid development of the game can be attributed to factors such as the increase in the level of competition and higher quality of training programmes which is greatly enhanced by the growth of team budgets (Fuller *et al*., 2009).

The modern game has also resulted in a number of law changes which were introduced for a variety of reasons (Kraak & Welman, 2014). Some of these changes have come in the form of the experimental law variations (ELVs) which were introduced into the Super 14 rugby competition in 2008 (Van den Berg & Malan, 2012). These were implemented *inter alia* to make the game safer, improve player performance and promote game continuity, as well as increase participation and enjoyment. Furthermore, technological advancements and commercial pressure have also played a role in implementing the ELVs (Kraak & Welman, 2014). As a result, coaches and coaching specialists were under pressure to find new ways to adapt to the changing game as well as improve the competitiveness of their team (Van den Berg & Malan, 2012).

This chapter will aim to construct a theoretical background for the study by summarizing performance analysis (PA) literature applicable to rugby coaching and the utilization of PA within the coaching process. This can provide greater insight into the manner in which coaches integrate PA into their coaching practices, as well as provide the coaching team with more information from which they can make informed decisions.

This chapter will be presented in five sections. Firstly it will provide an overview on the game of rugby, secondly; a brief overview on how professionalization has influenced the game, thirdly; the use of PA in rugby, fourthly; a section on rugby coaching and lastly; feedback from the coaching staff to the players.

2. RUGBY OVERVIEW

2.1. Background

Rugby union is a high intensity intermittent contact sport which originated in England in the early 19th century (Kraak & Welman, 2014). It is played on a rectangular field (dimensions of 100m x 70m plus up to 22m in each ‘in goal’ area) by two teams consisting of fifteen players per side over two halves of 40 minutes each at senior level and two halves of 35 minutes at first team high school level. The main objective of the game is to score more points than the opposing team by either scoring a try (presently worth five points), and successfully kicking the conversion (two points).

Other means of accumulating points include kicking a penalty or a drop goal which are both worth three points. A try is scored when a player crosses the opposing team's line and grounds the ball in a controlled manner in the in-goal area.

A rugby team consists of 15 players (with 7/8 reserves) which are divided into eight forwards and seven backline players The positions are listed as follows; 1 – loose head prop, 2 – hooker, 3 – tight head prop, 4 – left lock, 5 – right lock, 6 – left flanker, 7 – right flanker, 8 – number eight, 9 – scrumhalf, 10 – flyhalf, 11 – left wing, 12 – inside centre, 13 – outside centre, 14 – right wing, 15 – fullback.

In rugby the forwards and backs have different roles. The forwards are better known to be involved in activities that involve gaining and retaining possession whereas the backline players tend to be involved in the running aspects of the game. The forwards also perform more high intensity work compared to the backs and they are accustomed to having to perform more frequent activities with shorter rest periods compared to the backs.

2.2. Levels of play in South Africa

In South Africa rugby is played at school, tertiary, amateur, semi-professional and professional levels (Smit, 2011). It is a very popular sport around the world with the World Rugby (WR) representing 92 national unions (Duthie *et al*., 2003). According to the WR, there are currently 651 146 registered rugby players in South Africa (IRB, 2014). These players either represent national teams, their respective provinces, universities/clubs or they play at school level.

The provincial teams compete in the Currie Cup (U19, U21, Senior) or Vodacom Cup. The Currie Cup is the oldest annual South African domestic rugby competition and has been competed for by South African provincial teams since 1892 (Van den Berg & Malan, 2012). It features teams that either represents a province or a substantial part of the province. The 2015 format divided the unions into eight teams in the Premier Division and six teams in the First Division and these competitions provide a professional platform for rugby players within South Arica. With the introduction of the Super Rugby competition, this level of competition has become an important development platform and hence the competition was expanded to include

younger age groups, namely under 19 and under 21 provincial tournaments (Vahed *et al*., 2014). The Vodacom Cup is a South African third-tier rugby competition behind Super Rugby and the Currie Cup. It serves as an important platform for player development and has been contested since 1998 (Siebrits & Fourie, 2009).

The university teams in South Africa play in a variety of competitions namely; the FNB Varsity Cup (VC), FNB Varsity Shield (VS) and the University Sports South Africa (USSA) tournaments. The VC is the top tier university competition which has been competed for by the top eight University teams within South Africa since 2008. The VS is a second tier university competition which has been contested by six university teams where the top two teams gain the opportunity to play in the Varsity Cup in the following year. The USSA rugby tournament is a competition that is contested by all the rugby playing Universities in South Africa (USSA, 2014).

The Club system in South Africa plays an important role in the development of the players as provincial teams recruit players from clubs. There are a number of highly competitive club competitions in South Africa, for example, the Western Province Super League A, Eastern Province Grand Challenge league, Fidelity Security Moor Cup and the Blue Bull Carlton league to name a few (Smit, 2011). Furthermore, club teams participate in an annual competition currently named the Cell C Community Cup and first contested in 2013. The highest placed team from each of the fifteen leagues automatically qualifies for the tournament, along with the current holder of the title. In addition, the SARU selects wild card teams to compete, taking the number of teams to twenty. In the 2015 tournament an incentive was provided where the best young player, coach and manager taking part in the competition were rewarded with an international exchange to a top club in the United Kingdom (SuperSport official website, 2015). The tournament replaced the National Club Championships, as many clubs were affiliated to universities. Therefore in the new format, all university and other tertiary institutions are ineligible to take part in this tournament. The tournament has also been scheduled to run parallel with University rugby tournaments (VC and VS) (SARU, 2014).

The school teams are separated into fixtures according to their level of play, their region, as well as the history of competing against one another. Furthermore, school

teams take part in annual school provincial competitions which are played over a week in order to identify talent for the future. The national school tournaments are separated into three age groups, namely U13 Craven Week, U16 Grant Khomo Week and U18 Craven Week and Academy Week. The U18 Craven Week tournament first took place in 1964 and is contested by U18 school rugby players representing their provincial unions. It is currently rated the top school-boy rugby tournament in the world as it has the reputation of identifying talent and in many cases future Springboks (Durandt *et al*., 2011).

Lucrative sponsorship deals, contracts, as well as competition prize money has added an incentive for coaches to coach winning teams. For the players, the possibility of receiving team contracts, contract extensions, as well as added bonuses for their services has become the norm. For example, there is a financial incentive for Currie Cup teams to make the semi-finals and finals, as well as try to host these matches, with the team winning the final receiving R1.8 million and runner's up receiving R1.2 million in prize money. In 2013, it was reported that Western Province generated R13 925 000 from ticket sales by hosting the 2013 Currie Cup final and had to pay the visiting team R500 000 to cover their travel costs. In addition, teams hosting a semi-final had to pay the visiting team R250 000 to cover their travel costs (Van der Westhuyzen, 2014).

There is also a financial incentive for players to perform in order to negotiate better playing salaries for future seasons, for example, a Currie Cup player in South Africa can be paid between R500 000-R700 000 per year if they have limited Super Rugby experience and can receive between R1.5 million to R2.5 million per year if they play in Europe with the same experience. However, these values increase with playing level. For instance, Currie Cup players with more Super Rugby (20 games) experience receive more money, that is in South Africa, R1.5 million to R2.5 million per year and R3.5 million to R5 million per year in Europe. In addition, senior Springbok rugby players can earn up to R4m-plus per year (including provincial contract, win bonuses, commercial work, etc.) compared to R6m-plus per year which they would earn in Europe and R8m-plus per year in Japan (Van der Westhuyzen, 2014).

2.3. Professional rugby

When the game became professional in 1995, teams improved the way they prepared for the season in order to adapt to the changes of the modern game (Duthie *et al*., 2003). Since 1995 there has also been significant changes in the players' physical attributes, as described by Fuller *et al*. (2013). The physical attributes under investigation included the body mass, changes in stature, age and the number of players by position in English Premiership first teams. The results showed that the mean stature of players in all positions increased, with significant trends being noted in the fly-half and prop positions. The mean body mass of the players also increased with the fly-half and back-row players being significantly heavier. The average age of players decreased in all positions, but the trend was only significant for props. The researchers concluded that over the past decade, elite rugby players became taller, heavier and younger with significant changes being observed in fly-halves, props and back-row players.

A number of other factors have also contributed to the improvement of the game (Duthie *et al*., 2003; Trueman, 2014). An example is the modifications made to the rugby ball since 1995. The Gilbert rugby ball (the official ball used in South Africa) has seen changes in its surface, for example, in the 2003 Rugby World Cup Gilbert introduced the Xact match ball which had a more aggressive pimple pattern which was higher up on the ball with fewer pimples spaced out further than the previous balls. The ball's performance in the lead up to the tournament saw both New Zealand and The British and Irish Lions switching their allegiance to Gilbert and joining South Africa, England and a host of other nations, clubs and competitions around the world. This was due to the increased grip the ball provided for the players which was speculated to reduce unforced errors, and improve players' kicking performance. The technology of the Xact ball was further improved in 2005 at the Hong Kong sevens when a patented-star shape grip pattern (first ever departure from round pimples) was added to the ball which was also used at the 2007 Rugby World Cup (Trueman, 2014). This ball was designed to produce the same kicking performance as the ball used in the 2003 World Cup with the difference being that it provided better grip for handling.

The rugby ball went through another development where the Virtuo ball was introduced at the 2011 Rugby World Cup. It was a major topic of debate among commentators as it saw players' kicking statistics drop compared to their club and previous international performances (Trueman, 2014). This ball had a new internal bladder which was specifically developed to retain the pressure of the ball. The ball also had a new valve shape which was designed to redistribute the weight of the valve along the seam of the ball in order to improve its rotational stability, therefore promoting truer flight and increased accuracy. The weight of the ball was also increased in the valve in order to improve stability during passing as well as maintaining the rotational spin during a pass or a kick for longer.

The modern rugby ball has been a big improvement compared to the old leather ball which was used in the amateur era. The old leather balls would get heavy and slippery in wet conditions. It is therefore safe to say that the rugby ball used in the professional era has played a role in the improvement of player skills (Green & Gold Rugby, 2012). Research comprising laboratory and on-field tests, as well as discussions with players and administrators are ongoing to further improve the ball and maintain its consistency during tournaments (Trueman, 2014).

The introduction of a retractable roof over the rugby pitch has been a further addition which has come with the professionalization of rugby. The advantage is that games can be played during bad weather conditions and the spectators can still look forward to a good, well contested game. The disadvantage, however, is that the indoor arena may affect the flight of the rugby ball compared to playing on an open surface (Guardian, 2011). This can affect the kicking accuracy of the kickers and lead to bad kicking performances. Overall, the changes in the field conditions have allowed for a much faster game (Green & Gold Rugby, 2012).

The modern game was also characterised by changes in the laws of the game. (IRB, 2014). These law changes have been introduced to fundamentally develop the sport for a number of reasons; player safety, enhance participation, promoting game continuity as well retain the integrity and development of sport (Williams *et al*., 2005; Eaves *et al.*, 2008). WR constantly reviews, and if necessary, amends the laws to ensure safe and enjoyable rugby is being played (Biscombe & Drewett, 2010).

Vahed *et al*. (2014) studied the effect of law changes on the South African Currie Cup Tournament teams during 2007 and 2013 using fifteen KPIs and they also assessed the effect of the law changes on the profile of the game. The researchers revealed that the profile of the game had changed to a more continuous, dynamic game with a decrease in time spent at the rucks/mauls and subsequent rucks/mauls, as well as fewer set pieces (scrums and line-outs).

3. PERFORMANCE ANALYSIS IN RUGBY

3.1. Background

PA is the collection of information from sport performances with the goal of developing an understanding of the sports to enhance future performances and decision making. It involves the investigation and assessment of specific aspects of an individual's or team's performance in a competitive sport (O'Donoghue, 2006). Coaches will usually be interested in tactical and technical aspects of the sport, patterns of play, as well as individual players' work rates. Therefore, coaches will set out KPIs as a target measure for an individual's or team's performance and then collect specific data which directly investigates these aspects of the performance (O'Donoghue, 2006). PA also allows the coaches to categorize specific events that occurred during the game which allows the coaching staff to create an objective view and statistical account of actions and activities during the game. This information may be used when providing feedback to the team (Carling *et al*., 2008) and coaches may use it for future planning and strategizing.

Hence, PA in sport is defined as the collection of information involving the movements that relate to a sport performance with the goal of developing an understanding of the sport and to enhance future performances and players' decision making (O'Donoghue, 2006; Wright *et al*., 2013). This process invariably leads coaches to a better understanding and interpretation of the various aspects of the game (Hughes and Bartlett, 2002).

PA has also been described as the combination of biomechanics and notational analysis and how specific movements relate to sport performance (Bartlett, 2001). In

particular, it is the area of sport science that looks at individual aspects pertaining to a sport as well as the effectiveness of a team or individual (O'Donoghue, 2006). Biomechanical analysis specifically involves the study of the fine details of movement techniques, and is usually performed in athletes who take part in individual sports (Bartlett, 2001). There are instances when a particular skill, such as a kick at goal in rugby, is under investigation. In this instance, PA is carried out in a practice setting (O'Donoghue, 2006) and feedback is immediately given to the player. Further examples include the analysis of a player's golf swing or an athlete's running stride (O'Donoghue, 2010). In rugby, biomechanical analysis focusses on breaking down skills, as well as identifying specific movements that contribute to the successful execution of a specific technique such as evasive running (side step or swerve), kicking, passing, line-out jumping, line-out throwing, tackling and scrummaging. This analysis allows the coaches to better understand some aspects of the game that include the coordination of multi-directional movements achieved by the players during the game (Vahed *et al*., 2014).

PA also provides a link between performance and other aspects of sport science such as technical, physical and psychological requirements. In addition, with the knowledge of movement patterns that can be deduced from biomechanics and the use of notational analysis to determine physiological demands during training, training programmes can be designed to specifically meet an individual's or team's demands (Gabbett *et al*., 2008).

PA can therefore range from the technical analysis or mechanics of an individual's skills (biomechanical aspect) at one end to game analysis (notational and time-motion analysis) at the other (Vahed *et al*., 2014). In general, technical analysis focusses on the mechanics of a certain skill, whereas game analysis measures the outcomes and tactics employed by the individual, team unit or whole team (Agnew, 2006).

A reason for conducting PA is to provide insight and understanding on how coaches can integrate their coaching philosophies into their coaching practice. Furthermore, it affords coaches the opportunity to retrieve information about their own coaching as well as players' performances in order to allow them to make informed decisions with

the goal of enhancing future performances. In addition, coaching specialists and players have also had to improve their understanding of performance due to the upsurge in the level of competition as a result of professionalization in a number of sports (O'Donoghue, 2006; Wright *et al*., 2013).

In the past, coaches relied on memory and hand written notes to observe analyse and recall key events during the game (Carling *et al*., 2005). However, with the escalation in the frequency of events occurring during a game or competition there are potential limitations in coaches' capacity to give an accurate and objective analysis of key events when analysing a team's performance in this manner.

A study was conducted on experienced, qualified, soccer coaches (with a minimum of 6 months experience after obtaining their qualification) to recollect critical events during 45 minutes of a football match (Laird & Waters, 2008). Coaches were asked to watch a video of a previously recorded game. An older game was used (7 years old) as it was considered important to select a game which the coaches are not familiar with to avoid observer biases. After completion of the 45 min half, the coaches were given a questionnaire on the type of events they recalled. The results showed that the qualified coaches were able to recall 59% of the critical events of the soccer game. This result is 17.2% higher than a previous study on novice coaches (Franks & Miller, 1986), suggesting that the coach's experience played a role in the recall of specific events.

Franks (1993) compared the observational accuracy between novice and expert coaches upon viewing a video showing a gymnast's performance. The novice group consisted of seven physical education students (21 to 29 years old) with no gymnastic experience other than public school physical education classes. The expert group consisted of seven gymnastic coaches (26 to 45 years old) who had an average of 11.7 years of coaching or judging and 7.7 years of competitive gymnastic experience. The study participants were given instructions on an experimental video in order to familiarize them with the test procedure. A sample video was played in segments and stopped at selected frames to place emphasis on the beginning and end of the gymnast's routine. The participants had to observe the video and then answer questions about the test performance. The researcher concluded that

experienced coaches were more likely to report that there were differences in the routine when there were no differences and did not notice differences between the gymnast's routines any better than inexperienced coaches. It was also suggested that it may be influenced by the patterns of coaching that the coaches develop over the years which may lead to observer bias. In addition, if a coach works with the same individuals for a lengthened period of time, they may focus less on observing an athlete accurately. It also depends on the level of the coach. For example, if the coach works with elite athletes, they may place less emphasis on strengths and weaknesses compared to a coach who works with beginner or intermediate level athletes who will place more emphasis on identifying strengths and weaknesses (Crissfield, 1998). PA will aid in limiting these errors and allow coaches to make objective observations during the analysis with the goal of improving their teams' performance. In addition, the information gathered will assist both the coaches' and players' decision making, therefore enhancing future performances (O'Donoghue, 2010).

Over the last decade, there has been a noticeable increase in the utilization of PA tools within professional soccer (Carling *et al.*, 2009). For example, Blaze *et al.* (2004) reported that nine out of ten English Premier League soccer coaches that responded to an on-line survey used computerised notational analysis. Furthermore, the Head Performance analyst at Manchester City Football club in 2012 commented on how the game had developed over the last ten years and at how teams that are looking to gain a competitive advantage are utilizing PA (Soccermetrics Research, 2012). The growth in the utilization of PA tools has been attributed to the increase in the number of companies who provide this service to teams and the accessibility of PA tools to coaches. Furthermore, the latest software is also user friendly which contributes to widespread use (Wright *et al*., 2013).

The role of the performance analyst has become prominent in team coaching structures where they conduct PA and provide feedback to the coaching staff as well as the team (Wright *et al*., 2012). In this scenario, the coach and the performance analyst will discuss and agree on the type of KPIs which should be observed. The KPIs chosen can also be used by specialist coaches to direct the planning and management of the players' exercise training programmes. For example, if one of

the PIs selected is the number of rucks lost in a game, the analyst will observe the number of rucks lost during the game and report back to the coach who can either alone, or with help of the coaching staff, find ways and train players to secure the ball during the rucks. In addition, the performance analyst can also conduct PA at the game venue and provide immediate feedback to the coaches during the game (Liebermann *et al*., 2002). This information, as well as a relevant remedy can be relayed to the players on the field for immediate implementation and possibly more successful outcomes.

PA can be broken down into different stages. Figure 3.1 shows the coaching process and the importance of analysing play in stages. The first stage (observational phase) involves the collection of information, either during the performance/game or after. The second stage (analytical phase) involves analysing the information either during or immediately after the performance/game. During the third stage (planning phase), depending on what is needed to be explained, a member of the coaching staff provides feedback to the players or individual athlete. The information can be presented to the team/athlete in many different ways, for example, a whole video or segments of video material can be shown to the whole team or a specific group of players depending on the message the coaching staff would like to convey (O'Donoghue, 2010). Therefore it is important for coaches to select the correct PIs as well as communicate with the performance analyst on what aspects of the performance need to be presented to the team. These PIs are influenced by performances in previous matches as well as training loads of the players and are considered during the preparation of future training sessions. PIs will also be influenced by what goals the team wants to achieve moving towards the next game (Franks, 2004).

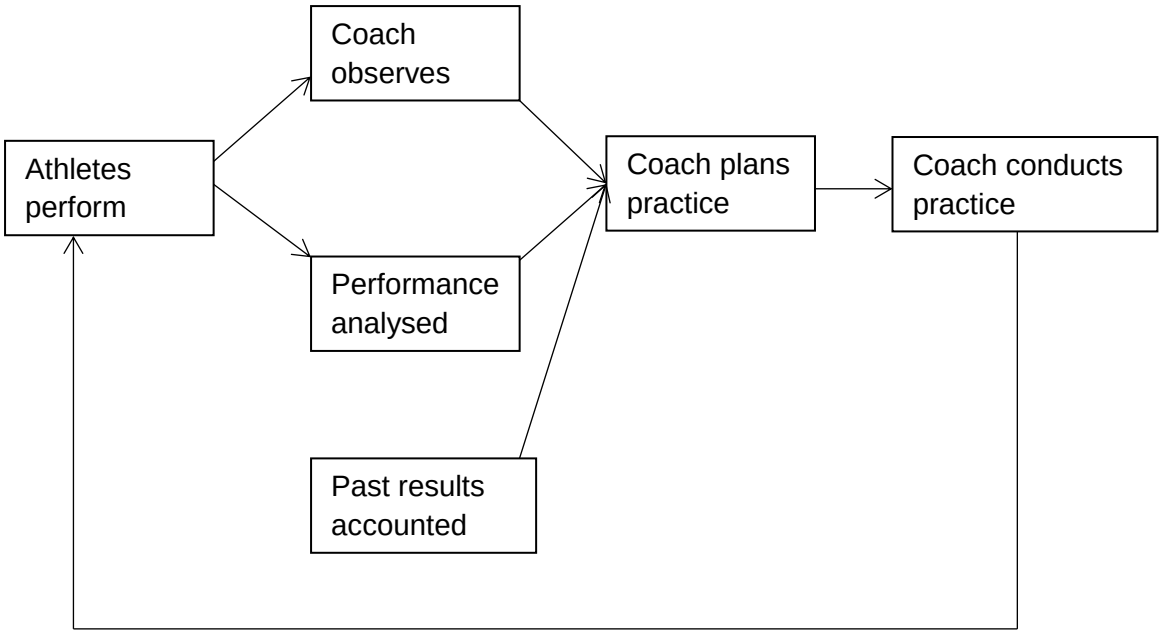

Figure 3.1: The coaching process adapted from Franks (2004).

3.2. Key Performance indicators

KPIs can be defined as the selection of specific characteristics or action variables of some or all aspects of a performance (Hughes & Bartlett, 2002; Jones *et al*., 2004; James *et al*., 2005). Within an individual sport such as tennis, this could be the number of successful first serves completed as a percentage of the total number of serves. In a team sport such as rugby, this could be the number of rucks formed during the game. The statistics can either be used to compare different performances by an individual athlete, or a team with other team members or team performances, or it can be used in isolation to assess the performance of an athlete or team alone (Hughes & Bartlett, 2002).

Coaches have to identify specific performance behaviours before they can tailor a coding system to effectively measure their KPIs (Hughes *et al*., 2012). In other words, they have to categorize specific events that occurred in training or matches in order to create an objective and statistical account of what occurred during the match (Carling *et al*., 2008). The performance analyst plays the role of providing additional feedback to the coaches and the team based on a systematic and objective analysis that shows if the target objectives were reached during the performance (Agnew, 2006). Hughes and Bartlett (2002) defined basic rules with

regard to applying KPIs to any sport. In every case, the success of the team is relative to either your opponent's or the team's previous performances. In order to interpret the data objectively, the collected data must be compared to the aggregated data of teams on the same level of play, i.e. same league or competition. Furthermore, the distribution of the actions must be compared as a percentage against the number of times that the action occurred (Hughes, 2004).

KPIs in sport are separated into four categories, that is; *match classification indicators*, *technical indicators*, *tactical indicators* and *biomechanical indicators*. In addition, these indicators can be further separated into scoring indicators or indicators measuring the quality of performance. Some examples of scoring indicators include; number of tries, penalties, kicks, ratios of succesful kicks at goal from total kicks at goal, whereas examples of quality indicators include; tackles, turnovers and passes/possession(Hughes *et al*., 2012).

Match classification indicators provide a recording of the most important events during games. Examples in rugby include: scoring (tries, penalty/conversion kicks and drop kicks), line-outs, scrums and turnovers.

Van Rooyen *et al*. (2010) investigated ruck frequency as a predictor of success in the 2007 Rugby World Cup (RWC). They observed that 58% of the teams that won their games during the pool stages had a higher ruck frequency compared to their opponents. Furthermore, during the knock-out stages, all the matches were won by teams with the fewest number of rucks during a game (Van Rooyen *et al*., 2010).

Ortega *et al*. (2009) analysed the differences in game statistics between winning and losing rugby teams in the Six Nations Tournament from 2003 to 2006. The researchers observed that winning teams on average had values that were significantly higher in points scored, conversions, successful drops, mauls won and line breaks, possessions kicked, tackles completed and turnovers won. In contrast, losing teams had significantly higher averages for scrums lost and line-outs lost.

Tactical indicators give an indication of the decisions the team makes in certain periods during a game, as well as the pattern or style in which the team choose to

play during the game. It also reflects how the team paces themselves during the game, as well as what areas of play they focus on. For example, in what part of the field the team will run the ball, kick for territory or where certain moves will be executed.

Vaz *et al.* (2012) analysed the Six Nations Rugby Championships games from 2005-2009. They reported that more kicking territory was gained by teams playing at home. This gives an indication that home teams focussed on dominating territory by kicking compared to teams playing away from home. This tactic of home teams probably relates to the players' familiarity with the field and weather conditions and their confidence to kick.

Vivian *et al*. (2001) analysed the playing patterns of elite rugby players who participated in the Six Nations, World Cup and the European club rugby in the 2001-2002 season. They looked at specific skill demands for each position in which they analysed on and off the ball supporting activities with the number of actions carried out by a player being recorded. It was shown that there was a steady increase in the number of actions from league level through European Cup up to International level. Flankers had an increase from 31 to 37 actions per game; interestingly attacking options made up 57% to 58% of their total actions at all levels. Furthermore, international flankers made fewer tackles than those in lower playing levels. It can be speculated that the greater tackling ability of the players surrounding the flankers at higher playing levels. In addition, the scrum halves at higher levels recorded more actions compared to those that were at lower levels, namely 29 at league level, 36 at European level and 50 at International level (Vivian *et al*., 2001). This may be a reflection as to how more competitive the higher level performances are as well as how much more demanding the game is on players at higher levels.
Tactical indicators can therefore be used to assess specific aspects in the game and this information may be useful in future performances.

Technical Indicators are used to measure and reflect how successful a certain skill is performed during a game, such as goal-kicking in rugby. Within rugby, examples of technical indicators would include the analysis of the execution of a tackle, kicking technique, line-out throwing technique. This allows the coaching specialist to see

how successful a specific aspect of the game is being executed during a performance. Normalisation of numbers is important as it compares actions within the game against the opposition's actions or previous team performances. Hughes and Bartlett (2002) showed how important it is to normalize rugby data into percentages or ratios. For example if team A conceded 12 turnovers and team B 8 turnovers, it may be assumed that team B performed better in this aspect of the game. However, if team A had 48 possessions and team B 24 possessions, then team A obviously had a better performance as their ratio of possessions per turnover conceded was better compared to team B.

In the study conducted on Six Nations Rugby Championship teams (Vaz *et al*., 2012), it was reported that more passes were completed by teams playing at home compared to travelling (away) teams. In addition, less tackles were made by home teams compared to away teams. With more home teams winning their games, the prior statistics (passes completed and tackles made) reflect that teams at home had more possession of the ball in hand. Furthermore, research observing the performances between winning and losing teams saw that the forwards who better executed specific skills at set pieces, such as scrums and line-outs, had better scrum and line-out techniques compared to unsuccessful opponents (Hughes & White, 1997). This shows that technical aspects play a role in the outcome of a performance and can contribute to what levels individual players and teams reach.

Biomechanical indicators focus on how specific aspects of the game or an individual skill can be broken down mechanically by analysing specific movements and techniques. In rugby these will include the execution of a scrum or a maul where each individual player has a specific role to play to dominate the opposition. Individual aspects include player movements such as performing a side-step. Other examples include kicking, line-out throwing, tackling as well as passing. Biomechanical analysis allows coaches and players to understand how to improve specific aspects of the game in order to have an advantage over their opponents, as well as improve the success rate of executing certain skills during the game (Hughes & Bartlett, 2002).

Research has shown that sport biomechanists have generally focussed their analyses on sports where the execution of a specific coordinated multi-segmental movement is required. These are sports where the analyst evaluates specific skills which play a role in the performance of the athlete or team and then together with the coaching specialists, ways are explored to improve the skill (Hughes & Bartlett, 2002; Knudson, 2007). For instance, in an individual sport such as gymnastics, athletics and tennis where a correct technique is of utmost importance in executing the skill (Hughes & Bartlett, 2002). In rugby, a player's side-stepping or change of direction capability can be broken down into the approach, foot-strike and toe-off (Wheeler & Slayer, 2010).

Biomechanical evaluation has also been used to observe certain aspects of the game such as the line-out, scrum as well as how the players enter the contact situation. For example, researchers showed that injuries caused by the contact situation could be reduced if players had a better understanding of dynamic impact, impact techniques and how to protect themselves during a collision with an opponent (Budescu & Iacob, 2008).

3.3. Performance profiles

With most sport being more complex and faster due to professionalism, the application of simplistic analyses of raw sports data could be highly misleading. Thus the development of PIs has led to the formation of performance profiles which can help the coaching staff to understand the physical loads on the players (Vahed *et al*., 2014). These describe the pattern of performance from an analysed individual or team. The aim of performance profiles is to assist in the prediction of future performances (Hughes *et al*., 2002; Jones *et al*., 2004). Furthermore, setting up performance profiles can help the specialist coach better understand the events and tactics implemented by teams which can also provide some prediction for future performances (Jones *et al*., 2004; Robertson & Joyce, 2014). However, O'Donoghue (2006) affirmed that it is crucial to select the correct PIs when choosing to develop performance profiles. Within rugby examples of KPIs include goal kicking and cover tackling which can be grouped under the profile of kicking and tackling. This allows the coach to group multiple PIs with similar actions into a single

performance measure for a match due to performances and execution skills varying between matches (Bracewell, 2003).

Figure 3.2 shows how tasks are combined into skill sets which can then be grouped into a single performance (Agnew, 2006). Initially, the sport-specific tasks related to successful performance are identified. These are then used to group similar tasks into skill sets (PIs). As previously stated, examples in rugby would include goal kicking and cover tackling which could then be grouped into skill sets such as kicking and defence (Bracewell, 2003).

Figure 3.2. The construction of performance and ability profiles (Adapted from Agnew, 2006).

In order to create performance profiles and assess the true averages for tasks and for different players, between three and seven matches should be analysed (Hughes *et al*., 2012). The ability of a player cannot be determined by a single performance due to sampling variability and situational constraints. Therefore, the ability of a player, also known as form, is a longer-term accumulation of performances (Bracewell, 2003). This process is one that uses comparisons in order to determine how successful tasks were carried out. Therefore, in order to make an accurate assessment, results should be compared to opposition teams or previous team performances.

Parsons and Hughes (2001) conducted a study on rugby players' performance profiles across three levels of competition. Information was collected from ten Welsh international matches. The study focussed on the players' ball skills activity, where in particular attacking actions were observed. The attacking actions were further defined as either 'with ball' or 'without ball'. 'With ball' options included the basic skills; passing, catching and running. The results showed that certain playing positions needed to practice more without the ball skills, in particular the flankers

who had 128 ‘without ball’ attacking options, compared to 90 ‘with ball’ actions. It was assumed that these results were possibly due to flankers supporting the ball carrier into contact rather than making carries themselves. To put these numbers into context with other playing positions, the locks had the second most ‘without ball’ attacking actions (n= 90) and in contrast the scrum-halves had zero, although they had 310 ‘with ball’ attacking options (Agnew, 2006). This study shows how the performance profiles of players in different playing positions can be used to understand the differences in work demands and actions executed.

Jones *et al*. (2004), using novel methods to interpret KPI’s, selected 18 PI’s that were to be compared over a number of rugby games. Performances were compared to previous performances in an attempt to depict relative performance levels of each PI. They used a method which attempted to standardize individual match values and it was suggested that it would allow coaches to isolate specific areas within the game where performance levels were lower or higher than previous standards. This was done by firstly identifying specific behavioural elements as a measure of performance for the team (Hughes & Bartlett, 2002). This involved compiling a list of team behaviours that were used in previous PA publications. Thereafter a panel of three members who had between them 40 years of PA and rugby experience, refined the list of team KPIs. Following the refinement, the list of PIs was presented to a panel of three elite rugby coaches who had 50 years of combined experience for validation purposes. They provided their feedback and appropriate changes were made to the list (Jones *et al*., 2004). From this analysis, researchers were able to find both statistical and practical differences between winning and losing teams over the season which provided the first progression towards the prediction and modelling of team performance in elite rugby (Jones *et al*., 2004). They suggested that coaches could use this information to model training sessions for future performances. However, in practice, this ideology is not feasible as coaches will have different views on which PIs they favour due to their coaching styles and philosophies (Hughes *et al*., 2012; Wright *et al*., 2013).

Another example of identifying and modelling performance profiles was illustrated by Ortega *et al*. (2009) during research on the differences between winning and losing rugby teams during the Six Nations Tournament where 58 games were analysed

between the 2003-2006 seasons. The researchers grouped 28 PIs into three categories namely, 'points scored' (number of points and how the points were scored), 'phase of play' (how teams obtained the ball and how they used it) and 'game development' (technical and tactical aspects of the game).

They showed that winning teams had significantly higher PIs for points scored, conversions, successful drops, mauls won, line-breaks, tackles completed and turnovers won. On the other hand, losing teams had significantly higher PIs for scrums and line-outs lost. These results showed that, specifically in the scrum and line-out, winning teams lost fewer balls compared to losing teams (winning teams obtained an efficacy of 90% in both actions). The results also showed that the winning teams tend to kick more, use the maul as an attacking option, as well as break the defensive line more often than losing teams. Lastly, on defence the winning teams completed more tackles (94% completed tackles) and recovered more balls compared to losing teams (Ortega *et al*., 2009). This is a good example of how performance profiles can be used to monitor performances during training and matches.

4. RUGBY COACHING

4.1. Background

Coaching can be defined as the process where an individual or team is empowered to achieve a specific goal (Bennie & O'Connor, 2010). The role of the coach is to create an environment where the athlete or team can learn and be motivated to perform to the best of their ability. In addition, it includes them being able to effectively communicate with the athletes, assist them in developing their skills and monitoring their progress. The monitoring process is an on-going cycle that sees coaches evaluating, intervening and providing feedback to their team with the goal of enhancing their performance (Carling *et al*., 2005). It also involves the coaches having the ability to analyse the technical and tactical aspects of a team's performance and make changes that will benefit the team for future performances (O'Donoghue, 2006).

4.1.1. Technical skills

Technical skills are the ability of a player to move their body to perform a specific task, for instance, to successfully execute a desired movement such as in a gymnastic routine, or be able to repeat a specific movement a number of times such as in running and rowing (Martens, 2012). Within rugby, coaches can focus on technical aspects such as kicking, scrum, line-outs, passing, tackling, rucking and mauling to identify the specific movements that are crucial to execute the technique (Vaz *et al*., 2012). Furthermore, when Hughes and White (1997) observed the performances of forwards in winning and losing teams, they concluded that the forwards from winning teams had better scrum and line-out techniques compared to unsuccessful opponents.

4.1.2. Tactical skills

Tactical skills describe the ability of the players to make decisions to perform specific actions that will allow them to gain a competitive advantage over their opponents, such as passing the ball into the space away from the opponent (Martens, 2012). In team sports, the way the coach employs tactical skills may be influenced by a number of factors such as the characteristics of the team. For example, in the 2003 World Cup, the England rugby team's strengths rested on having strong forwards and a good kicking game. England's fly-half scored the highest number of points in Rugby World Cup history and most of the points came from penalties.

Other aspects that influence the way a coach tactically approaches the game include the opponents or the conditions in which the team will play. A statistical analysis done by the WR during the 2003 Rugby World Cup showed that the number of tries decreased as the tournament proceeded, that is from 7.5 tries on average in the pool stages, 4.5 tries per game in the quarter finals down to 1.7 tries per game in the semi-finals and final stages of the competition. This analysis also showed that the number of penalty goals successfully kicked increased from 4.1 penalty goals in the pool stages, 5.8 in the quarter finals up to 6.3 penalty goals in semi-final and final stages (Mitchell, 2003).

Tactical skills can also refer to the intensity at which the team wishes to perform at during certain periods of the game, as well as where they execute certain actions during the game, for example, when to retain the ball or kick for territory.

Kraak and Welman (2014) analysed ruck-play as a performance indicator during the 2010 Six Nations tournament. They observed that attacking teams, irrespective of where the team was ranked, were mostly successful during ruck time if they had one more player involved in the ruck than the team defending. Furthermore, defenders were more successful when they committed only one defender to each ruck. This is an example of the type of information that coaches can use to plan their team's tactical approach to ruck play.

Coaches' tactical decisions can be influenced by the coaching style that they employ (Martens, 2012). Their coaching style can be influenced by their previous experiences or by bias and emotions (Hughes & Bartlett, 2008). The latter are clearly subjective observations and these have been shown to be unreliable and inaccurate. For example, soccer coaches could only recall 59.2% of important events that occurred during 45 minutes of a soccer game (Laird & Waters, 2008). Therefore, if coaches rely on subjective observations, they may miss out on important information.

4.2. Coaching styles

Over the last decade, coaching has become a considerable subject of academic research. Research has focussed on how coaches operate as well as ways to effectively educate them. However, most of this research has focussed on the history of coaching and has lacked reference to long established patterns within coaching practices which originated from what was passed down by previous generations (Jones & Kingston, 2013). This was argued to have led to being limiting as the coaching apprentice was exposed to only one style of coaching, whereas coaching requires flexibility and adaptation to external factors such as the team's opponents.

The professionalization of sport has also stimulated the growth of coaching as a profession (Lyle, 2005). Many teams, especially professional sports teams have different coaching specialists who are responsible for, among other, fitness and conditioning, and technical aspects of the sport. These coaching specialists have

made it a priority to apply their knowledge to the specific field that they coach. It has also been proposed that coaching should define its future identity as an integrated professional area, functioning within a wider field of sport and physical activity and not as it is currently categorized, that is, volunteer coach, professional coach and the preparatory category of pre-coach (Duffy *et al*., 2011).

Coachesing styles influence how they decide what tactical and technical aspects are important, how they conduct training and how they treat their team. To date, three distinct coaching styles have been described namely; command style, cooperative style and submissive style (Martens, 2012).

The command style is where the coach makes all the decisions and the team is expected to respond to all the coach's commands and tactics. This has been the dominant style used by coaches in the past (Martens, 2012). This type of coaching enables coaches to establish safety and discipline parameters, control the players as well as ensure that the players work towards a specific goal. However, this style of coaching limits the players from making their own decisions on the field (Martens, 2012).

In the modern game, most coaches tend to use the cooperative style of coaching. With the cooperative style both coaches and players work together and share decision making responsibilities (Gilbert & Jackson, 2004). This style has also been seen as a good way to develop leadership within the team. This coaching style allows the decision making to be shared between the coach and the players. To achieve this in rugby, the coach provides the drills, structure as well as rules, but allows the players to learn to set their own goals and strive towards them (Martens, 2012).

Coaches who utilize a submissive style make as few decisions as possible by providing minimal guidance and a few instructions to their players. The coach takes on the role of a babysitter and the players have the freedom to explore various options, which may improve player creativity (Callej, 2001; Perry, 2013). However, this style of coaching does not guide the players or give them a goal to work towards.

Some coaches rely solely on their coaching style when making decisions as they believe that the use of technology may limit their spontaneous decision making during a game. However, as previously mentioned, subjective observations cause coaches to miss out on important events during a game. This is why the use of PA is essential in the modern game as it is important for coaches to have objective measures and data to improve their teams' performances and to supplement their chosen coaching style (Ronayne, 2004; Holstein, 2010).

In a quest to develop and nurture coaches in all sports, many international sport associations and federations have structures in place to support countries in the education and qualification of coaches. For instance, the International Amateur Athletic Federation (IAAF) introduced an education programme called the Coaches Education Certification Scheme which is linked with the European Framework for the Recognition of Coaching Competence and Qualifications (Duffy *et al*., 2011). Other federations which have employed these education programmes include the WR and Union des Associations de Football (UEFA). UEFA developed a system to allow coaches to function at different levels within the professional game according to their licenced grade (UEFA, 2011). However, with the exception of major professional sports such as rugby, soccer, cricket, basketball, baseball, among others, many athletes and sports teams of minor sports still rely on volunteer coaches. These coaches also operate on their own and do not have the luxury of specialist coaches in their teams to provide them with relevant knowledge that coaches in professional set ups receive.

A significant contribution to develop coaches through these international organizations has been made possible by the financial contribution of the Olympic Solidarity Commission which provides education programmes for all the National Olympic Committees (NOCs), particularly in areas around the world with the greatest needs. The programmes have been instrumental in promoting the development of coaching by creating efficient structures and providing training courses at different levels for coaches. Furthermore, organizations such as the World Anti-Doping Agency (WADA) educate coaches on doping issues (Olympic Solidarity Commission, 2015).

The WR also saw it as important to educate rugby coaches all over the world. Not only does the WR offer coaching courses to develop the players' rugby skills, but they also have courses which educate prospective coaches on how to approach their coaching role (IRB, 2014). The coaching courses are separated into different levels with the WR level 2 course discussing how to develop rugby skills for a team. The first aspect that the course covers is the coaching style and coaching process. This section educates the coaches on how to select the most appropriate coaching style to suit the goals of their team. The WR (2014) specifically described two coaching styles that can be employed, namely the coach-centred style and the player-centred style (IRB, 2014).

The coach-centred style is mostly used during training sessions involving very structured drills. In this case, the coach will provide most of the instructions with little input from the players and other coaching specialists. The training is technique driven and the focus and outcome of this style is on performance and winning (IRB, 2014).

The player-centred style is where the coach will plan drills and exercises that help improve the players' decision making ability. The coach provides an environment for players to express themselves and where they are not afraid to make mistakes. The focus of this style is mainly for the individual and team's development. The coach also allows other coaching staff to have an input on team tactics and in planning the team's future (IRB, 2014).

The WR level 2 coaching course manual (Developing Rugby Skills), is designed to equip coaches with skills to coach a team. It covers the type of coaching styles that a coach can use, how the coach should plan and deliver a training session, how to analyse key factors of rugby as well as aspects on player safety. In addition, it looks at what the functional roles of the players are during a game, how to select a team as well as the laws of the game (IRB, 2014).

In addition, the South African Rugby Union (SARU) launched BokSmart, a programme that educates all coaches involved in rugby in South Africa about the

safety aspects of the game. All coaches in South Africa are encouraged to attend the BokSmart courses and obtain their qualification before getting formally involved in coaching. Moreover, to assure that coaches are kept up to date, the coaches' BokSmart licence must be renewed every two years (Boksmart, 2014).

However, both WR and the SARU courses do not include the aspect of observing and assessing a team performance which is important when coaching. (Wright *et al*., 2013). One method that allows coaches to achieve this is by using PA.

5. FEEDBACK

5.1. Background

The coaching process is a continuous cycle where an individual or team is empowered to reach a certain goal (Hughes & Franks, 2008; Bennie & O'Connor, 2010). The coach's role is to create an environment where the athlete or team can learn and be motivated to perform to the best of their ability. In addition, it includes being able to effectively communicate with the athletes, assist them in developing their skills and monitor their progress. Coaches achieve this by evaluating the performance and then provide feedback which can be incorporated into their training sessions with the goal of enhancing future performances. Furthermore, among other things, the success of the coaching process is dependent on how accurate the performance is analysed (Carling *et al.*, 2005; Hughes & Franks, 2008).

Players are expected to have the motivation and intent to always strive for better performances. One of the most important aspects that can affect their performance is feedback. If no feedback is provided to the players, the players will have no knowledge of alternate ways to better their techniques and will probably not change their performance. This will not happen because of the coaching process being flawed, but because of the coaches analysis process being limited (Lee, 2011).

The coaching process has mostly been associated with facilitating the process of providing feedback to the players. This is why it is important that the data collected during a team performance is objective, accurate, unbiased and as comprehensive as possible (Hughes & Franks, 2008). In order to successfully facilitate the feedback

process, coaches have to provide an environment where the players can observe and evaluate their own performance in a process known as intrinsic feedback, as well as the coaches providing the athletes with alternate ways to improve their performances, referred to as extrinsic feedback.

Intrinsic feedback involves the athlete using sensory information that comes from the external environment or the athlete's own body. Examples of intrinsic feedback in rugby include the sight of a rugby ball being kicked, the feel of a player's neck and shoulders during a tackle, the sound of the boot making contact with the ball and the overall feel of the player when they execute a specific skill during the game (Hughes & Franks, 2008). Furthermore, when coaches want the player to pay more attention to intrinsic feedback, for example, during the way they kick the ball, throw a line-out or execute a pass, they will first instruct the player to perform the skill and take notice of their body position and movements. They will then ask the player to evaluate and describe how the execution of the skill affected the outcome. This analysis will provide the player with a number of options on how they can improve the next execution of the skill (kick, pass and line-out throw). With the repetition of the skill, the player will improve their execution of the skill and will have the ability to detect and correct errors when they occur. This process of allowing players to evaluate their performance allows them to learn how to make adjustments during a game.

In addition to intrinsic feedback, players need to be able to obtain external feedback. This is known as extrinsic feedback and usually occurs as a result of players not being able to detect information about their performance on their own and therefore needing an external source that compliments intrinsic feedback. Within rugby, extrinsic examples include the verbal comments made about the scrum technique of a front-row forward, or in determining whether a tackle was executed correctly within the rules of the game; a slow-motion replay of a line-out performance as well as the movement of players on the field during the game. The information received during extrinsic feedback usually compares the player's execution of a skill with what should have been done (Hughes & Franks, 2008).

Extrinsic feedback can accelerate the process in which the players access information which can result in the player achieving improved performance in a shorter period of time. The success of this process depends on the experience and

background of the coach to detect errors and provide useful information about a specific movement or skill and that will benefit the player to execute the skill better in future performances (Hughes & Franks, 2008; Wright *et al*., 2013).

Traditional methods of coaching and providing feedback usually involved the coach making decisions based on their perceptions, previous experiences and beliefs. However, this way of providing feedback has been shown to be subjective, unreliable and inaccurate (Wright *et al*., 2013). It has been shown that coaches are not able to remember all the events that occur during a sport performance, let alone provide any detailed analysis. For rugby coaches at school level, there is an even greater task in providing feedback as spectator involvement as well as the coaches subjective views about the performance make it difficult for the coach to provide objective and meaningful feedback to the team. To a similar degree, coaches usually remember distinct events in the game such as outstanding performances, controversial decisions and actions that occur after stoppages in the game, where as non-critical events in the game are usually forgotten. Remembering only the critical incidents during a game may impair the coach's ability to remember the build up to those critical events (Hughes & Franks, 2008).

A possible method of improving the feedback process is the introduction of notational analysis. This process allows information to be collected in an objective, unbiased and reliable way. It combines the use of video analysis in conjunction with computer technology to collect data for post-PA and provide the most accurate feedback to the team as well as individual players. Furthermore, notational analysis allows coaches to compare different playing patterns of opposing teams, therefore allowing them to create PIs that highlight the aspects of performance that contribute to their own team's success.

The use of video analysis provides a benefit for the player as the video can be replayed allowing the performance to be viewed a number of times, therefore reducing observer bias and providing more detailed information about the performance. It also helps the coaches explain what aspects of a performance were executed well as well as those that need to be improved in future performances. In rugby this may include the number of unforced errors, number of rucks won/lost,

tackles made/ missed and number of line-outs won/lost, to name a few. Essentially the role of the coach during video feedback would be to determine the critical elements of a successful performance by providing cueing information and augmented feedback to the players (Hughes & Franks, 2008).

Research has shown that there are a number of ways in which the coach can present video based feedback to the players. This is as a result of computer-based technologies integrating quantitative performance information with video recordings (O'Donoghue, 2006). Other advances include the ability to integrate video recordings, match event databases and include data from systems that are used in related areas in sport science such as heart rate monitors (Hughes & Franks, 2008). To optimally use and benefit from the available technology, many teams employ specialist coaches to assist with training and analysis of performances (Vahed *et al*., 2014). PA also allows the coaches to have an objective statistical account of the game prior to providing feedback to the team with the help of the coaching specialist in charge of video analysis (Carling *et al*., 2008).

Specialist coaches usually present edited video recordings as a method of providing effective feedback. These videos can be effectively structured to maximize the ability of the player to learn about their performance. The coaches can compare player performances to previous performances showing them where they have performed well and where they need to improve. The coach will break the video down into edited versions depending on what message they want to convey to the players (O'Donoghue, 2006). These can be broken down into the following categories:

5.2.1. Match videos

Match videos are completed digital video recordings of the game which can be stored on a computer and used in the future. It is important for coaches to receive video copies of the whole game to allow them to observe all aspects of the game. This then allows them to highlight what aspects they would like to feedback to the team according to the coach's PIs and performance profiles. On occasion, players may also request the match footage in an attempt to view aspects of the game from

their playing point of view. Rugby coaches usually view the full match videos to evaluate the success of their chosen PIs and performance profiles of the team, as well as the movement patterns of the team during the game (O'Donoghue, 2006; Deutsch *et al*., 2007).

5.2.2. Areas for improvement

Coaches pinpoint specific aspects of the game which were not well executed and focus on ways to improve these aspects for future performances. They use PIs and performance profiles as measures of performance. The results from previous rugby games and tournaments can also be used to test how successful the selection of certain PIs were in determining team performance. For instance, the researchers that analysed the differences in game statistics of winning and losing rugby teams in the Six Nations Tournaments (2003-2006) found that losing teams lost significantly more of their scrums and line-outs (Ortega *et al*., 2009).

Furthermore, since the professionalization of rugby, teams have placed more emphasis on finding novel ways to improve their performance (Duthie *et al*., 2003). As a result, most professional teams will utilize coaching specialists such as a kicking coach, scrum coach, backline coach and tactical coach to assist the head coach. These coaches each focus on a specific aspect of the game as well as find ways of improving the performance of the particular aspect of the game. The players' involvement in analysis has also been found to be a benefit in preparing them for future performances (O'Donoghue, 2006).

Furthermore, coaches also offer feedback in different forms according to the player's learning style. The coaches will talk during the video feedback session and provide a feedback sheet that shows what players executed well, as well as areas in which they can improve (Francis & Jones, 2014).

5.2.3. Videos focussing on specific techniques

Certain analysis focusses on certain skills and in conjunction with coaching specialists. These may include more technical aspects of play such as the scrum and line-out in the game as well as ways in which they can be improved (Budescu & Iacob, 2008; O'Donoghue, 2006). These edited videos are also important for

biomechanical analysis as researchers have shown how injuries caused during a collision could be reduced if the correct techniques were used by the players (Budescu & Iacob, 2008).

5.2.4. Opposition videos

These videos allow the coaches to provide feedback on how they will tactically perform against a specific opposition. It may also highlight certain areas of weakness in their opponents which the team can capitalize on. These videos also focus on the performances of individual players who have a critical influence on games. This provides the coach with the opportunity to target key players of the opposition and also provide ways for the team to nullify their strengths (O'Donoghue, 2006).

5.2.5. Individual player's strengths and weakness

Video analysis of individual players focus on the individual's performance and whether their execution of certain skills was successful. Coaches will point out the positive aspects of their performance. It is player specific and not position specific as a player may make a positional change within the same game for example a centre moving to the wing.

In addition, each game has to be analysed using post match analysis in order to repeatedly view the passages of play before selecting which aspects were positive or negative (O'Donoghue, 2006). This method has been used by the Norwegian Football Association where feedback on negative aspects was individually provided to the players (Olsen & Larsson, 1997). It was shown that the feedback process should be player-specific as the players will react differently to specific ways in which negative feedback is presented to them. Also, the feedback provided must be relevant to the player's level of play (Groom *et al*., 2011). Research conducted on elite rugby players' perceptions on PA showed that when players were allowed the opportunity to view their own performances, it provided them with a learning tool to view their mistakes and find ways to improve their performance in future. This also allowed the players to view their performance in an objective manner thereby enabling the coaches to give accurate and objective feedback (Francis & Jones, 2014).

5.2.6. Selection and recruitment clips

These video edits may indirectly help coaches in the selection process. The coach has the opportunity to repeatedly view the positive and negative aspects of players' performances. This also allows the coach to make an informed decision upon viewing detailed analyses of players' performances. It also gives the selection panel more confidence in their decision making for team selection (O'Donoghue, 2006).

5.2.7. Motivational video

These are video edits that usually consist of video clips taken from one of the team's recent performances and prior achievements from previous performances. These would also include passages of play where the team performed well or an individual player linked well with team-mates. The video is usually accompanied by motivational music of the team's choice with the best aspects shown in slow motion. Music has been shown to encourage players and enhance their adherence to aerobic exercise (The Sport Journal, 2008). Coaches can also use video edits of training sessions along with the team performance for the players to understand the hard work that they put in to produce their level of performance. Players usually focus on their mistakes during performances; therefore this allows the players to focus on the positive aspects of their performance.

5.3.1. Extrinsic feedback

Feedback that comes from an external source (also known as augmented feedback) enhances intrinsic feedback by adding more information to what is naturally available to the performer (Bortoli *et al.*, 2010). This feedback process is used by coaches to provide motivation as well as help the player correct errors, reinforce proper execution of their skills by reducing the discrepancy between a desired and an actual outcome (O'Donoghue, 2006; Bortoli et al., 2010). The types of augmented feedback include the knowledge of results (KR) and the knowledge of performance (KP). KR is externally presented information about the outcome of performance or the achievement of a goal. It does not describe the outcome, but tells the player whether they achieved the goal. KP provides the player with information about their movement attributes that resulted in the performance outcome (O'Donoghue, 2006).

5.3.2. Positive effects

The use of augmented feedback helps the players understand their own perceptions about the success of the outcome as a result of the information received through intrinsic feedback. This allows the players to have a continued successful performance if the outcome was good, or change their performance if it was not. It also allows the coach to differentiate between qualitative and quantitative feedback. Qualitative is feedback is where the coaching staff tells the team on what they liked and did not like about a performance and how they can improve future performances, whereas quantitative feedback is based on the information gathered through performance analysis of the game and is presented through numerical scales. The positive effects from an outcome based feedback are generally observed during practice. The repetition of this feedback process allows the players to be guided to a correct response by being provided with enough information to encourage a change in their performance (O'Donoghue, 2006).

5.3.3. Negative effects

The use of augmented feedback, if not implemented correctly, could negatively impact performance. Knowledge of an error may cause the player to over-correct leading to more errors performed. Furthermore, the level of feedback that should be provided to the player, should match their skill level (Groom *et al*., 2011).

It is also important for coaches to not give the players too much feedback as this may lead to players becoming dependent on extrinsic feedback which may lead to poor performance when it is withdrawn (O'Donoghue, 2006).

6. CONCLUSION

With the professionalization of rugby in 1995, there has been a need for coaches to constantly monitor the progress of their team as well as ensure that they are well prepared for the matches throughout the season (Mellalilieu *et al*., 2008). Furthermore, there has been an increased responsibility on the coach due to the increased number of games per season, the level of competition as well as the introduction of law changes. This has also led to teams recruiting coaching

specialists to assist the coach with the changes that are occurring within rugby as well as to prepare the team to meet the demands of the modern game throughout the season (Green *et al*., 2011; Smart, 2011). In addition, the introduction of coaching specialists has to be specific to the areas at which they coach. They also need to assist the coach in the process of evaluating the game as potential limitations have been shown in the coaches' capacity to observe, recall, feedback and provide an accurate analysis of key aspects during live performances (Carling *et al*., 2005).

This led to introduction of PA which allows coaches to evaluate the actual aspects of the performance in training or matches before providing feedback to the team or individual player. The primary reason for conducting PA is to provide an insight and understanding to the coaches and players about the performance in order to allow them to make informed decisions with the aim of enhancing future performances (O'Donoghue, 2006; Wright *et al*., 2013).

Furthermore, the process of player monitoring is on-going where the coach has to evaluate performance, intervene and provide feedback to the team. This process has been made simpler as coaches can identify PIs that allow them to provide more accurate feedback (Carling *et al*., 2005). This will also aid in limiting errors so that coaches can make objective decisions as their coaching success is dependent on how accurately they analyse and provide feedback to the team about the performance (Carling *et al*., 2005).

However, research has focussed on how coaches operate and on the history of coaching respectively and has lacked reference to established coaching patterns. There has also been limited research on how coaches use PA within rugby; moreover no research has been conducted on how coaches in South Africa engage with PA.

CHAPTER FOUR

METHODOLOGY

1. Research design

In accordance to the proposed research objectives (Chapter 3), this study followed a descriptive study design. Data collection was done using an electronic survey, consisting of both open-ended and closed-ended questions. Data from the survey was both qualitative and quantitative in nature.

2. Study population

2.1. Participants

Eighty-one coaches involved in different levels of South African rugby (provincial, university and school rugby) were identified through the webpages of the respective rugby unions. Schools were selected based on being ranked in the top 30 rugby playing schools of the year 2014 in South Africa and the contact details of the coaches were obtained from the schools' websites. The coaches were requested to participate in the study by being personally contacted by phone or email.

2.2. The questionnaire

The online survey was developed using the SUrvey software tool developed by Stellenbosch University. The questionnaire was modified from previous research conducted on elite and semi-professional coaches of various sports in order to suit the current study (Wright *et al*., 2013). As the current study only focussed on rugby coaches, some of the questions were slightly modified to reflect this. Furthermore, the modified questions were aimed to determine whether performance analysis played a role in team selection, as well as coaches' description of their own coaching philosophies. The key themes included: *Demographic information:* The coach's age, gender, level of coaching and the level at which they coach. *Analysis process*: The duration to execute and interpret analysis and the information produced. *Feedback*:

How feedback is presented and when it is produced. *Implications for coaching practice*: How the data collected influences the coaches' preparation for future performances, as well as how they relay this information provided by PA back to the players to help them develop. *Key performance indicators*: Factors that influence the coaches' selection of specific key performance indicators. *The value of PA*: The extent that the coaching staff values PA and the role of the performance analyst. The coaches were provided with a glossary of terms used in PA to assist them with completing the survey.

The survey was distributed in the following manner. A link was sent via email to all the coaches, where they were asked to volunteer and take part in the study. The questionnaire consisted of key themes and 38 questions where coaches either had an option of selecting the most appropriate answer, multiple answers or fill in an open response answer (Appendix B).

Furthermore, the coaches were asked to answer a number of closed questions to assess the level at which the coaches are involved in rugby. This was important in allowing the comparison between coaches coaching at the same level and at different levels within South African rugby. This also allowed the researcher to compare how the coaches with different levels of experience utilized PA. In addition, there were some questions, which required an open response option to allow the coaches to answer about their experiences. There were also a few questions that used the Likert scale. This allowed the researcher to measure the attitudes, concepts and opinions relating to the coaches' engagement with performance analysis. These questions were asked in open format to allow the respondents to express and explain themselves in their own words. (Wright *et al*., 2013).

A pilot study was conducted on a sample of 15 coaches before the online survey was made available to coaches. A few questions were modified concerning how PA influenced team selections as well as coaching philosophies. Questions involving the placement of the teams in their respective competitions were removed due to the majority of coaches not wanting to reveal this information. The coaches that took part in the pilot study did not participate in the main survey.

3. Ethical aspects

The study protocol was approved by the Ethics Committee of Research Subcommittee A at Stellenbosch University (DESC-Magwa/2014)(Appendix A). Each coach received an informed consent form with a clear explanation of what the study entailed. This was available online and only seen when they had agreed to take part in the study. If a respondent answered “no” to the final question of whether they agree to participate in a voluntary manner, the link to the questionnaire was closed.

4. Assumptions

It was assumed that all coaches were honest when answering the online-survey. It was also assumed that coaches had a full understanding of what was required from them before they took part in the study.

5. Limitations

The researcher had no control over whether the coaches would complete the online survey.

6. Delimitations

The study was limited to South African rugby coaches at sub-elite level.

7. Statistical analysis

The data was analysed using the statistical package for social sciences (SPSS v19.0). Descriptive statistics are reported as frequencies and expressed as percentages. The relationships between the different levels of coaches and certain outcome variables were calculated using Chi-squared tests for independent groups. Results were considered statistically significant if $p < 0.05$.

CHAPTER FIVE

RESULTS

1. Response rate of coaches to the online questionnaire

The online questionnaire was sent to 81 coaches, of which 51 responded. Five questionnaires were excluded, due to either coaches choosing not to participate (n=3), or coaches not complying with the inclusion criteria of the study (n=2). Therefore, 46 questionnaires were used for data analysis. This represents a response rate of 56.8%. The provincial coaches (71.4%) had the highest response rate to the questionnaire (Table 5.1).

Table 5.1. The response rates of the different levels of coaches who took part in the study.

	Provincial	University	School	Total
Potential number of coaches	21	30	30	81
Respondents	15	15	16	46
Response rate (%)	71.4	50	53.3	56.8

2. Personal information of respondents

The age range of coaches who took part in the study varied between 20 and 59 years. The majority of coaches in the total group were between 30-34 years (9) and 35-39 years (14).

Figure 5.1 shows the age distribution of coaches at school, university and provincial level. Most of the coaches at school (5) and university level (6) were between the ages 35-39 years. The majority of coaches at provincial level (4) were between 50-54 years old.

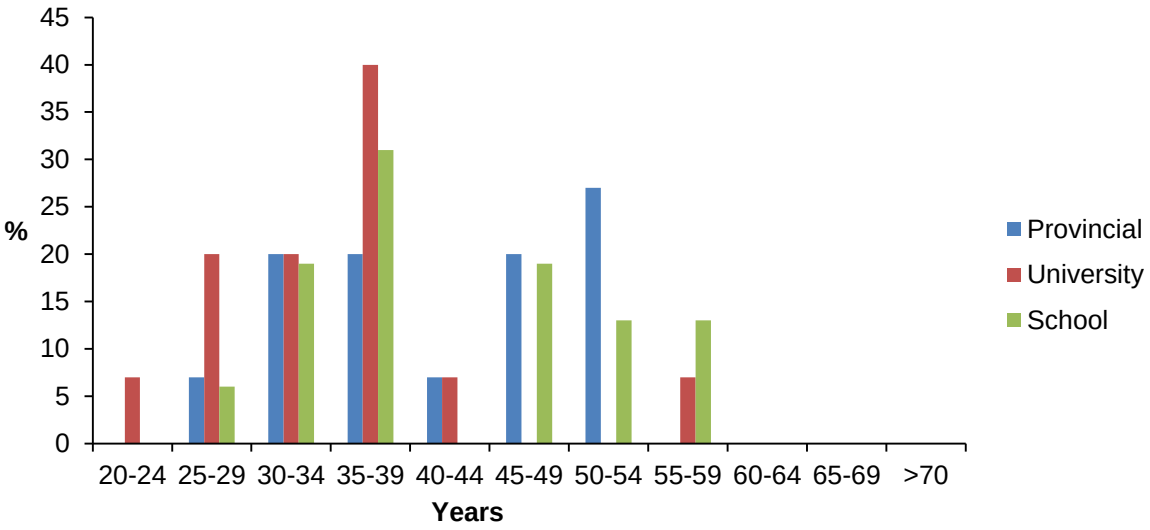

Figure 5.1. Age distribution of coaches at respective coaching levels

Table 5.2 shows that the majority of the coaches had an WR level 2 qualification (18), but this was not statistically significant more than the other levels of qualification ($p > 0.05$). Furthermore, at each respective coaching level, most of the coaches had an WR level 2 qualification (5 at provincial, 8 at university and 5 at school). Nine individuals indicated that they had a qualification other than an WR level 2 or higher, as well as SARU level 2 or higher qualification. These included WR level 1, SARU level 1, KZNRU level 5, Jake White's Winning Ways Coaching Course, Investec advanced coaches' course. One individual indicated that he had no formal coaching qualification.

Table 5.2. Coaches' highest coaching qualification.

	Provincial (n)	University (n)	School (n)	Total (n)
WR Level 2	5	8	5	18
SARU Level 2	3	1	2	6
WR Level 3	3	0	4	7
SARU Level 3	3	1	2	6
Other	1	5	3	9

The majority of the coaches (27) were working towards achieving an WR level 3 coaching qualification and Table 5.3 shows that most of these coaches were at provincial level (11). No statistically significant difference was observed between different coaching levels ($p > 0.05$).

Table 5.3. Coaching qualification which the coaches are working towards.

	Provincial (n)	University (n)	School (n)	Total (n)
None	2	2	5	9
WR Level 2	1	3	2	6
SARU Level 2	0	0	1	1
WR Level 3	11	9	7	27
SARU Level 3	0	1	1	2
Other	1	0	0	1

Figure 5.2 shows that the coaching experience of coaches ranged from less than 5 years to more than 16 years. The majority of the coaches have less than 16 years of experience (34). Figure 5.3 shows that the school coaches had the most experience with the majority of these coaches having more than 10 years of coaching experience (13). The provincial coaches had the least coaching experience with most of these coaches having less than 10 years of experience (9). There was no statistically significant difference in the experience of coaches at the different levels ($p > 0.05$).

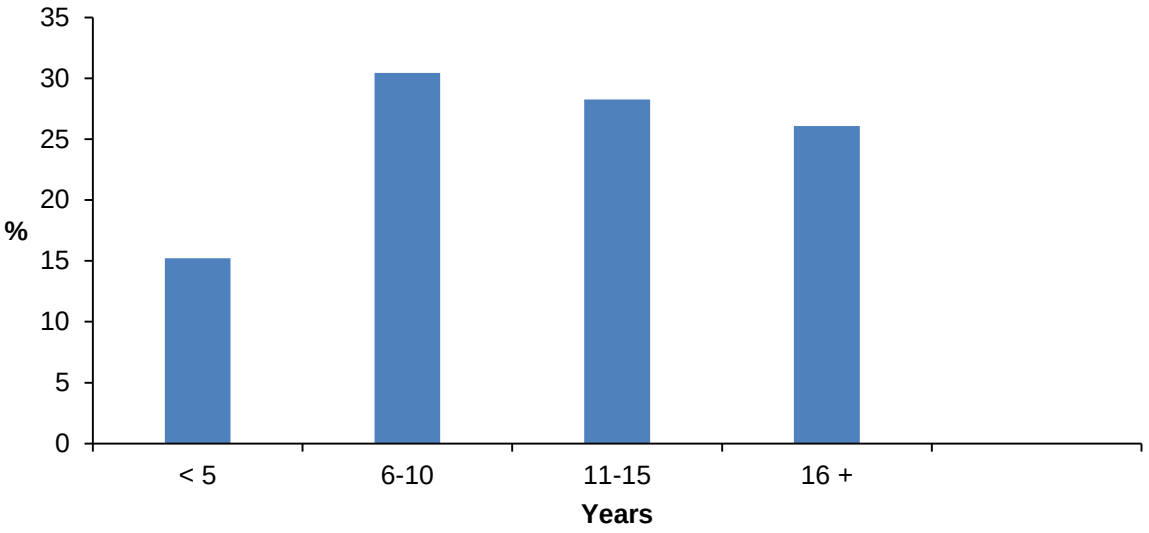

Figure 5.2. Coaching experience combining all levels of South African coaches involved in the study

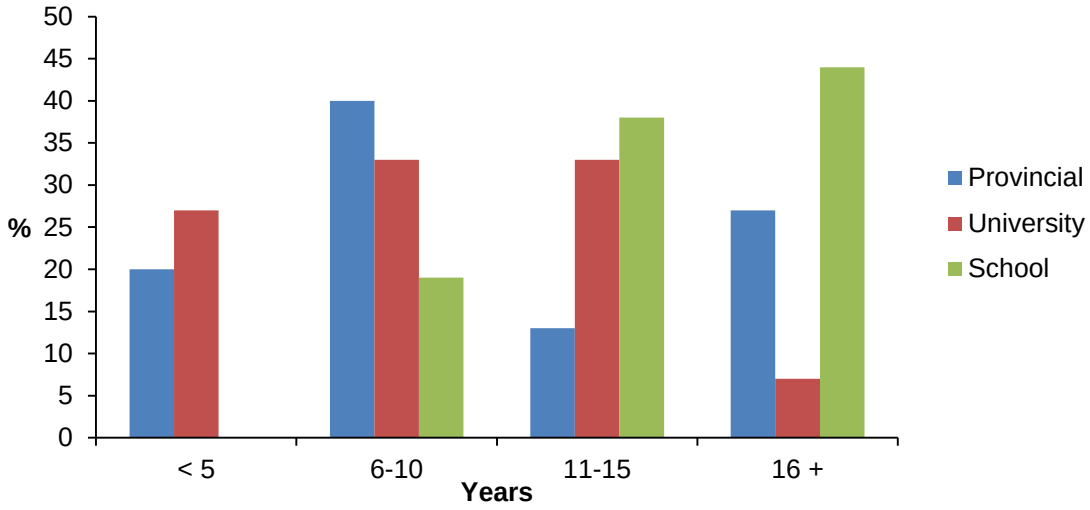

Figure 5.3. Coaching experience of respondents at school, university and provincial level

Except for coaches at school level, the majority are full time employed as a coach. There were statistically significantly more full time coaches at provincial level (14), compared to other coaching levels ($p = 0.004$). The majority of coaches at school level (9) consisted of part-time coaches who have other responsibilities within the

same organization (Table 5.4). No significant difference was shown between coaches at the different levels in terms of coaching years with their current teams ($p > 0.05$).

Table 5.4. Coaching role within the organization.

	Provincial (n)	University (n)	School (n)	Total (n)
Full Time	14	6	6	26
Part Time	0	4	1	5
Part Time supplemented	1	4	9	14
Volunteer	0	1	0	1

Table 5.5 shows that the majority of coaches have less than 5 years coaching experience with their current teams with most of these coaches being at university level (12). There were only two coaches, one at provincial and one at school level, who worked more than 16 years with the same team.

Table 5.5. Formal coaching experience with current team (years).

Years	Provincial (n)	University (n)	School (n)	Total (n)
< 5	9	12	9	30
6-10	5	3	4	12
11-15	0	0	2	2
16+	1	0	1	2

3. The utilization of performance analysis

There was a total of 44 coaches from the total group who utilized PA of which 41 received video footage. Therefore, results relating to video footage included 41 coaches and those relating to PA included 44 coaches. The majority of coaches (31) continually have access to video footage of their teams, while 10 coaches indicated that they rarely or never had access to video footage (Table 5.6). Provincial coaches (14) have statistically significantly the most readily access to video footage compared to other coaching levels ($p = 0.004$), while university level coaches (8) rarely or never had access to video footage.

Most of the coaches receive video footage within two days after the game (37). The provincial coaches had the fastest delivery time as the majority of these coaches receive video footage within a day after the match (13) compared to the coaches at university level who receive footage after two days (8) or receive no footage at all (3). More than half of the coaches (24) from the total group did not have access to a performance analyst to provide them with PA related information after the game. Most of the provincial coaches had access to a performance analyst (11).

In addition, most of the coaches (31) assisted in carrying out PA. The majority of these coaches were university coaches (12) who had the least access to a performance analyst (4). Eight of the coaches had other individuals who contributed to their PA. These included the PA being done by assistant coaches, a combination of the coach and assistant coach and physiotherapist, all coaches, as well as a combination of the coach and some players in the team.

Table 5.6. Accessibility of video footage to school, university and provincial coaches.

	Provincial (n)	University (n)	School (n)	Total (n)
Never	0	3	2	5
Rarely	0	5	0	5
Occasionally	0	2	2	4
Often	1	0	0	1
All the time	14	5	12	31

Figure 5.4 shows that the majority of coaches (20) spend 2 or 3 hours on post-match analysis. Figure 5.5 shows that most of these coaches are at school level. More school coaches spent less time on post-match analysis compared to most provincial coaches who spent 2 or 4 hours. There are two provincial coaches, one university and one school coach who spend seven or more hours on performance analysis.

The majority of coaches also carried out their own technical PA (27). More coaches at school level carried out their own technical analysis compared to other coaching groups. Sixteen coaches from the total group had other individuals who helped carry out technical PA. These include other coaching staff within the team, coaches from other teams, as well as players within the team. Furthermore, most of the coaches from the total group (17) spent 2 hours reviewing technical PA information. The provincial coaches on average spent more time reviewing technical PA information compared to other coaching levels, while the university coaches spent the least time reviewing technical PA (Figure 5.6).

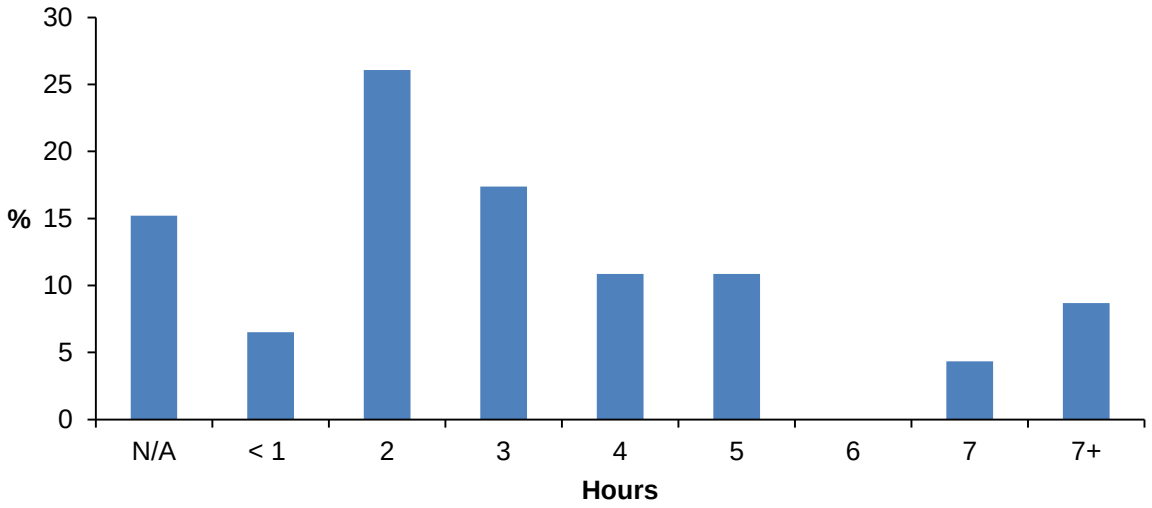

Figure 5.4. Time spent on post-game analysis following a game by all respondents

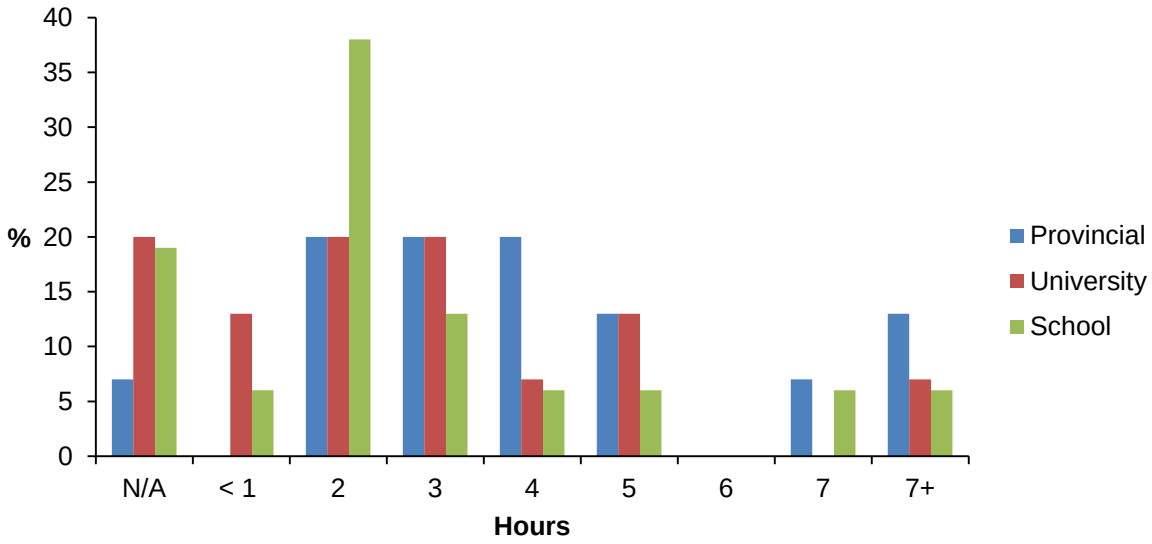

Figure 5.5. Time spent on post-game analysis following a game at school, university and provincial level

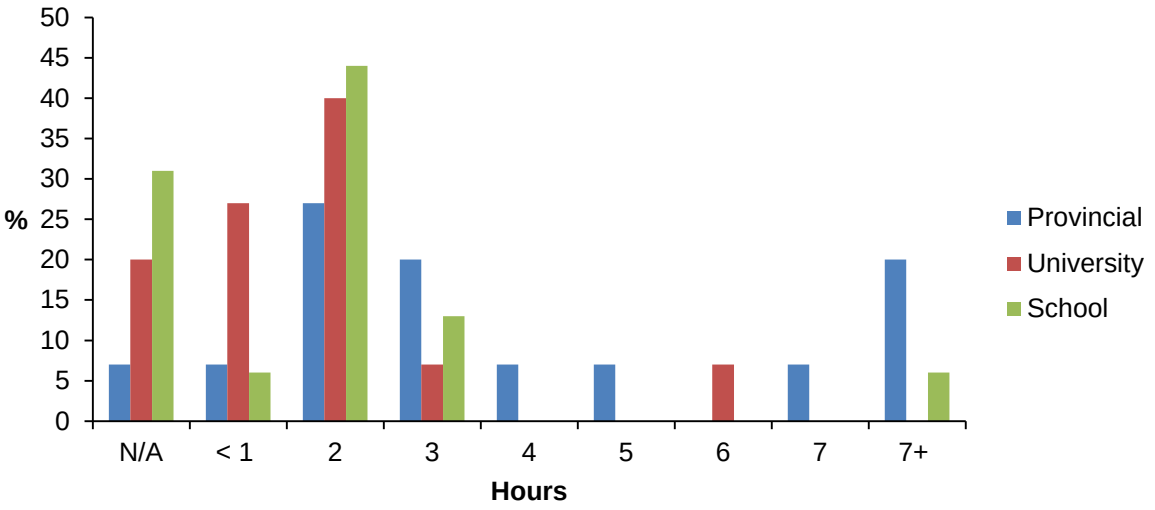

Figure 5.6. Duration spent reviewing performance analysis information at school, university and provincial level

As previously stated, more than half of the coaches (24) did not have access to a performance analyst to provide them with PA related information. However, most of the coaches at provincial level had access to a performance analyst (11). The majority of provincial coaches (13) regarded the relationship with their analyst as essential and very important. Most of the coaches at university (10) and school (8) level did not have a relationship with their analyst as they did not have access to one (Figure 5.7).

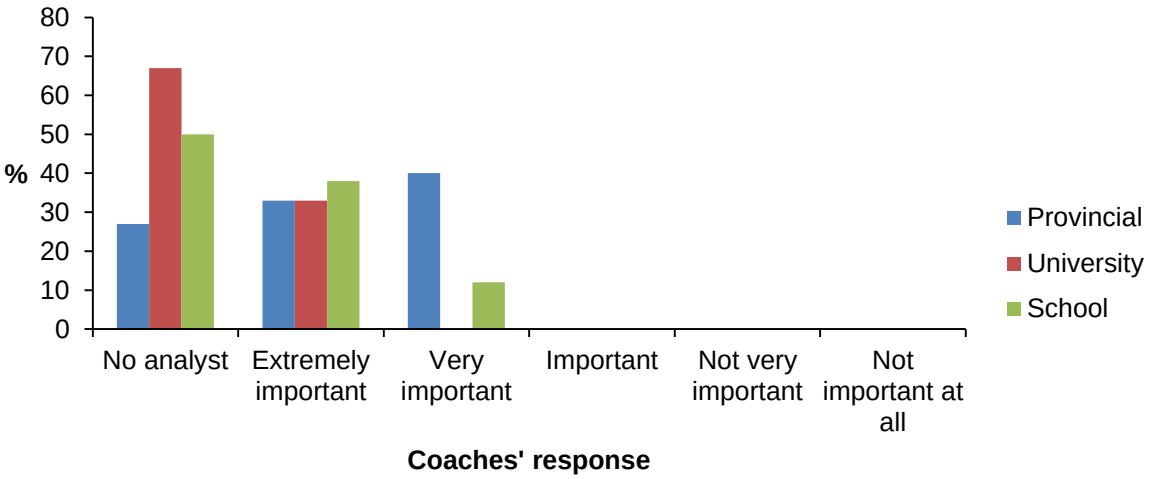

Figure 5.7. Coaches view on the importance of a relationship with the performance analyst at school, university and provincial level

4. Performance analysis and coaching practices

Figure 5.8 shows that the majority of South African coaches (28) at all coaching levels use PA all the time to inform their coaching process.

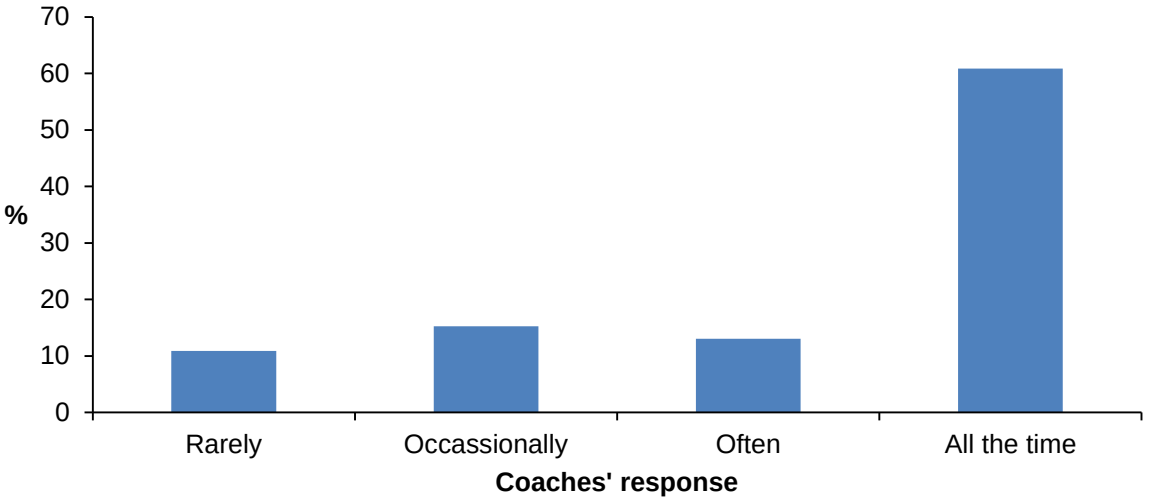

Figure 5.8. How frequently performance analysis is used to inform the coaching process

The majority of coaches who took part in the study never filmed training sessions (12), with the exception of most provincial coaches (5) who filmed their training on a daily basis. There were statistically significantly more provincial coaches who filmed their training sessions more frequently compared to other coaching levels ($p = 0.01$). Most of the university coaches (9) never filmed their training sessions (Table 5.7). Table 5.8 shows that most of the coaches (38 out of 46) find the use of PA in introducing changes into their tactics as essential and very important. In particular, most provincial (9) and school (9) coaches find the use of PA in developing and introducing changes to their tactics as essential. The majority of university coaches (8) find the use of PA as an aspect of introducing changes to their tactics very useful.

Table 5.7. The number of times coaches film training sessions at school, university and provincial level.

	Provincial (n)	University (n)	School (n)	Total (n)
Never	3	9	5	17
Daily	5	0	0	5
Weekly	3	3	3	9
Monthly	3	3	4	10
Yearly	1	0	4	5

Table 5.8. The value of changes in coaching that have been introduced using performance analysis.

	Provincial (n)	University (n)	School (n)	Total (n)
Not at all useful	0	1	0	1
Not very useful	1	0	0	1
Fairly useful	0	0	4	4
Very useful	5	8	3	16
Essential	9	4	9	22

5. Key performance indicators

Table 5.9 shows how coaches' selection of KPIs may differ from one game to another. There were no statistically significant differences in the coaches' selection of KPIs at the different levels ($p > 0.05$). The majority of coaches changed some KPIs from game to game (22), while 14 said their KPIs remained consistent from game to game. Interestingly, more provincial coaches did not change their KPIs from game to game (7), compared to those who made some changes from game to game (5). The majority of coaches at university (8) and school (9) modified their KPIs from game to game.

Table 5.9. The differences in how coaches select KPIs from game to game at school, university and provincial level.

	Provincial (n)	University (n)	School (n)	Total (n)
Remain consistent from game to game	7	3	4	14
Change complete set of KPIs from game to game	2	0	1	3
Some KPIs change from game to game	5	8	9	22

Table 5.10 shows that the majority of coaches' selection of KPIs (29) is influenced by their coaching philosophy (9 at provincial, 10 at university and 10 at school), with their being no statistically significant differences between coaching levels ($p > 0.05$). In addition, most of the coaches across all levels of coaching found the selection of the KPIs extremely important in their coaching practice (9 at provincial, 8 at university and 9 at school).

Table 5.10. The factors that influence the coaches' selection of KPIs at school, university and provincial level.

	Provincial (n)	University (n)	School (n)	Total (n)
Other coaches	1	1	0	2
Your opposition	1	2	4	7
Your coaching philosophy	9	10	10	29
Coaching literature	2	1	0	3
Gut instinct	1	0	1	2
Leave it to PA	1	0	0	1
Other (please specify)	0	1	1	2

Further analysis was performed to make comparisons among coaches who used PA all the time against those who did not use PA all the time. Firstly it has been noted that 31 coaches from the total group use PA all the time, compared to 15 who do not. Furthermore, there were no statistically significant differences in the ages of coaches who used PA all the time compared to those that did not use it all the time ($p > 0.05$). Coaches who used PA all the time were on average slightly older in years (41.2 ± 8.57 years) compared to the coaches that did not use PA all the time (35.7 ± 9.9 years).

Most of the coaches in the study had an WR level 2. However, of the coaches who used PA all the time, 7 had WR level 3, whereas none had an WR level 3 in the group that did not use PA all the time. There were no statistically significant

differences amongst the two groups with regards to coaching qualification ($p > 0.05$). There were statistically significantly more coaches (14) at provincial level who used PA all the time, compared to those who did not use PA all the time (1) ($p = 0.03$). The coaches who used PA all the time had slightly more coaching experience in years (12 ± 4.6) compared to the coaches who did not use PA all the time (9.4 ± 4.3), although this difference was not statistical significant ($p > 0.05$). There was also no statistically significant difference in the number of years the coach was with his current team between those who used PA all the time and those who did not use PA all the time ($p > 0.05$).

6. The value of performance analysis

Figure 5.9 shows that coaches at all levels find PA essential or very important (38). At provincial level, coaches value PA as either essential (7), or very important (7). The majority of coaches at university (12) and at school (12) also value PA as essential or very important. Only one coach at school level did not regard PA valuable in contributing their coaching process.

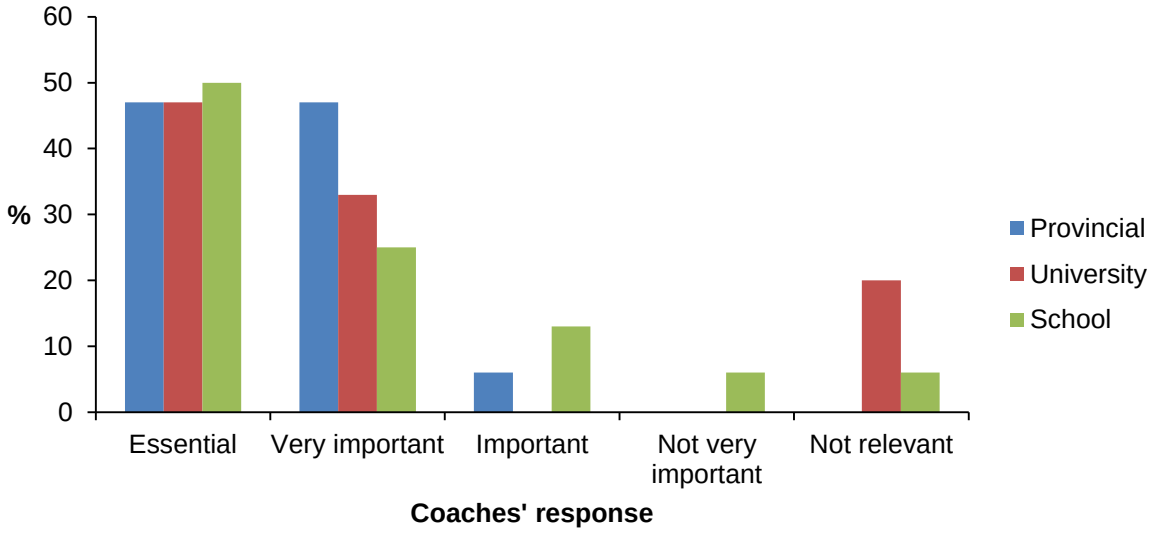

Figure 5.9. The coaches' value of performance analysis at school, university and provincial level

CHAPTER SIX

DISCUSSION

1. INTRODUCTION

The purpose of the study was to examine how PA was used by South African rugby coaches, in particular first team provincial, university and top 30 high school coaches, as well as how coaches at the different levels were currently using PA, implementing it into their coaching and if they were of the opinion that it has contributed to improving their team's performance. The chosen levels of rugby are known to be competitive in the development and nurturing of future national team players. The school rugby teams feed into the provincial and university leagues, whereas the university and provincial teams feed into the national team.

For the purpose of this study an online questionnaire was used which consisted of key themes namely; demographic information, analysis process, feedback, implications for coaching practice, key performance indicators and the value of PA. This discussion is therefore focusing on comparing the responses from coaches at different levels of competition concerning how they use performance analysis. The study also anticipated that it would not only highlight to what extent performance analysis information was currently being integrated into coaching practice, but more importantly to what degree the coaches valued performance analysis as part of their coaching job.

There has been one other study similar to the current study. The purpose of the previous study was to investigate how PA was used by elite sports coaches from various sporting codes (Wright *et al*., 2013). Therefore most of the findings from the current study will be compared to the previously mentioned study.

2. RESEARCH PARTICIPANTS

This study had an overall response rate of 56.8%. This was similar to a previous study that had a response rate of 46.0%, which surveyed New England high school football coaches about their understanding and management of concussions (Guilmette *et al.,* 2007). However, in a survey on South African rugby coaches regarding their knowledge of prevention, identification and management of concussions, the response rate was only 27.7% (Thomas *et al.,* 2011). The present study included only South African rugby coaches at provincial, university and the top 30 South African high schools who volunteered to participate. This was different to a previous study which surveyed coaches from a variety of different sporting codes, namely rugby league, hockey, football, basketball and rugby. Also, the coaches who responded in the previous study were not from a single sex (Wright *et al.,* 2013). This may to a degree limit comparisons that can be made with the current study.

The coaches who responded to the study consisted of fifteen (15) provincial coaches, fifteen (15) university coaches and sixteen (16) high school coaches. The provincial teams took part in either the Currie Cup or the Vodacom Cup competition. The university teams took part in either the FNB Varsity Cup, FNB Varsity Shield or University Sports South Africa rugby competition. The high school teams took part in their respective annual fixtures determined by their level of play, their region as well as history of playing against one another. The top 30 high school coaches from the year 2014 were contacted and asked to take part in the study.

The majority of coaches involved in the study had WR level 2 qualifications. This trend was also observed at each respective coaching level. This is the second highest coaching qualification in South Africa with the WR level 3 being the highest. Furthermore, there were coaches who had SARU level 2 or SARU level 3 qualifications. The SARU level 2 is equivalent to WR level 2, whereas SARU level 3 is equivalent to WR level 3. In order to qualify for the WR/SARU level 3 qualification, coaches had to meet certain criteria such as being the head coach of a team, being older than 21 years of age, having an WR level 2 qualification, completing a self-test on the WR rugby website, as well as completing a season diary. Furthermore, the WR level 2 coaching qualification is designed to provide the coaches with the

suitable skills to coach teenage and adult players in a club or school, whereas the WR level 3 helps coaches focussing on planning a season, delivering training sessions as well as reviewing performances throughout the season (IRB, 2015). The fact that most of the coaches had an WR level 2 qualification shows that the majority of coaches that took part in the study have the ability to conduct a training session without any supervision.

In a previous study in the United Kingdom on how coaches used PA, the elite coaches were either selected on the basis of being enrolled in the United Kingdom Coaching Certificate (UKCC) level 4 (formal coach programme for elite master coaches within the United Kingdom), or being affiliated with the school of sports tourism and the outdoors via professional engagement. The UKCC level 2 is similar to the WR level 2; therefore the previous study had coaches that had higher qualifications compared to the current study (Wright *et al.,* 2013). The present study also had coaches who had other qualifications apart from the ones previously stated. These included; WR level 1, SARU level 1, Jake White's Winning Ways Coaching Course and Investec advanced coaches' course. Only one coach reported that he had no coaching qualification.

In the present study the majority of coaches who took part can be considered experienced coaches, as only 15.2% of the coaches had less than 5 years formal coaching experience. This has been seen in other survey studies where coaches had similar formal coaching experience (Thomas *et al.,* 2011; Wright *et al.,* 2013). This result was also shown at each respective coaching level. Apart from the coaches who had less than 5 years formal experience, there is a decreasing trend in the number of coaches as the number in years of formal experience increased. This can be observed on Figure 5.2. This result contrasts previous studies where the number of coaches increased with the number in years of formal experience, with the exception school level coaches (Thomas *et al.,* 2011; Wright *et al.,* 2013).

Table 5.4 shows that 26 (56.5%) of the coaches involved in the study were full time coaches and 19 (41.3%) were part time. Of the latter group, 14 (30.4%) indicated that they had other roles within the same organization. Most of the part time coaches (56) were in the high school category and supplemented their coaching with activities

within the same organization. In other words, these coaches were possibly teachers at the school. Fewer of the coaches in the study by Thomas *et al.* (2011) (17%) were full time and the majority of participants coached at high school level (38.4%). Similar to the current study it can be assumed that these coaches were also teachers at the school where they coached.

3. PROVISION OF PERFORMANCE ANALYSIS

One of the primary roles of the coach is having the capacity to observe and assess performance (Wright *et al.,* 2013). It has been reported that coaches have a limited ability to recall key events during a performance. Franks and Miller (1986) showed that coaches were able to retain between 30%-50% of key events during a match. Subsequent to this study, more studies illustrated the limitations in human observation within coaching practice (Franks, 1993; Laird & Waters, 2008).

The introduction of PA has enhanced the coaches' observational capacity. The results from the present study show that the majority of coaches (80.4%) receive video footage within two days following a match. This is similar to the findings of Wright *et al.* (2013) who reported that a vast majority of elite coaches received video footage on either the same day or the following day of the game. The same trend was observed at the respective playing levels. This may be due to the fact that at many playing levels, it is a requirement for the home team to provide their opposition with video footage of the match within a specific timeframe (O' Donoghue, 2006). A minority of the coaches often receive the video footage only on an occasional basis. Of the three groups in this study, 53% the university coaches rarely received video footage. This can be attributed to the fact that a majority (73%) of the university coaches do not have access to a performance analyst. This is not the case for both provincial (93%) and school (75%) coaches where a majority of the coaches receive video footage all the time. It is a surprising finding that more school coaches had access to PA than university coaches.

More than a quarter (30.4%) of the coaches utilize video footage only occasionally or rarely. Possibly these coaches use PA when preparing or following an important match and that PA does not systematically play a role in their coaching practices.

In the current study, the majority of the coaches (67.4%) carried out the PA themselves. This was also observed at each respective coaching level (60% at provincial, 80% at university and 63% at school). This might suggest that these coaches are using a systematic approach to enhance their coaching practice and are aware of their potential limitations as a coach to recall and give an accurate unbiased analysis of key events during a match (Carling *et al.,* 2005). Further evidence supports this finding, as the majority of coaches spend 2-3 hours analyzing PA data following each match. These findings are similar to a previous study where most elite coaches spent between 1-3 hours reviewing their performance analysis data following a game (Wright *et al*., 2013). Figure 5.5 shows that provincial coaches spend between 2-4 hours analyzing data, where both school and university coaches spend between 2-3 hours. This provides further support to how important these coaches regard PA as part of their coaching practice. These results are in agreement with results by Wright *et al*. (2012) from English professional football. They reported that the majority of performance analysts working at academy and professional level within English professional football spend between 2-3 hours conducting post match analysis.

In the current study most of the coaches (58.7%) carried out their own technical performance analysis. At the differences levels, the results from this study show that apart from provincial coaches, university and school coaches carried out their own technical performance analysis. At provincial level, most of the technical performance analysis is conducted by other individuals (60.0%). This may be due to the majority of provincial coaches having access to a performance analyst (73.0%). Larger team budgets as well as financial investments from sponsors in the provincial set-up allow for a greater possibility of having coaching specialists to provide assistance with technical performance analysis.

Most of the coaches spend 2 hours reviewing information from technical performance analysis. Figure 5.6 shows for both the university and school coaches, the majority of coaches spend up to 2 hours reviewing this information, while the majority of provincial coaches spend more than 2 hours reviewing this information. It can be suggested that the university and school coaches spend less time compared

to the provincial coaches, as the majority of these coaches carry out their own technical performance analysis.

4. HOW PERFORMANCE ANALYSIS INFORMS THE COACHING PRACTICE

Prior to the availability of performance analysis footage and software, many coaches have relied on their memory as well as hand written notes to observe, analyze and recall important events during a game (Carling *et al*., 2005). However, there have been limitations shown in the observational and recollection capacity of coaches during live performances. In particular, a few studies showed that coaches were able to recall less than half of important events that occurred during a match (Franks & Miller, 1986; Laird & Waters, 2008). This is why PA has been important in allowing coaches to objectively view a performance as well as enhance the way they integrate this information to inform their coaching practice (O'Donoghue, 2006). The introduction of PA has therefore provided a whole new dimension in the operation and practices of coaches, which probably contributed to the development of the game at all levels.

Figure 5.8 shows that most of the coaches in this study who have access to PA use PA all the time to inform their coaching. The same trend was seen for coaches in each respective group in the current study. This result is similar to a previous study where the vast majority of elite coaches used PA to inform all levels of their coaching practice. Furthermore, the study highlighted that the majority of coaches (48.0%) identified PA to inform their coaching practice all the time (Wright *et al*., 2013). This gives further evidence that PA has become an integral part of the coaching practice of those who have readily access to PA.

The current study shows that more provincial coaches used PA all the time to inform their coaching compared to the other coaching levels. This may suggest that these coaches possibly have more accurate and objective analysis systems available to allow them to systematically monitor their team performance with the aim of improving future performances (Hughes & Bartlett, 2002). The current study supports this as the majority of the coaches (84.8%) acknowledged that the use of PA introduced changes to their style/tactics/game plan and was essential or very useful

(Table 5.8). This can be attributed to the fact that at provincial level the coach either has direct access to a performance analyst from an outside company, or a performance analysis may be full time part of the coaching team. Thus, these coaches would have regular access to video footage, as well as the expertise of a person who will analyze the results. The high access to a performance analyst can also be attributed to the fact that the majority of provincial coaches film training sessions on a daily basis, compared to most university and school coaches who never film training sessions as seen on Table 5.7.

In order for coaches to develop intervention plans and strategies that will enhance future performances, they should highlight critical events from previous performances (Jones *et al*., 2005; O'Donoghue, 2006). The majority of coaches surveyed during this study used KPIs to code important behaviours within the match. This is similar to the results observed in a previous study (Wright *et al*., 2013). Furthermore, most of the coaches (63.0%) highlighted their coaching philosophy as the main influence on their selection of KPIs. Similar results were observed across all levels that is, provincial, university and school, which is also in agreement with the findings of Wright *et al*. (2013). This suggests that the majority of coaches have the ability to objectively integrate their coaching philosophy into variables which they can use to analyze performances. This provides the coaches with strategies that can help them evaluate and compare their performances throughout the season.

In a previous study, it was highlighted that there was a degree of flexibility in the coaches' selection of KPIs (Wright *et al*., 2013). In other words some KPIs would remain the same while others would change from game to game. This is in agreement with the responses from the coaches in this study. However, the majority of provincial coaches' selection of KPIs remained consistent from game to game (47.0%), contrasting previous findings (Wright *et al*., 2013). This may be due to the fact that provincial set ups are professional and have more access to PA information to allow these teams to select specific KPIs for their specific game plan. There were 33.0% of provincial coaches who indicated that there was an element of flexibility in their selection of KPIs. The fact that the majority of coaches in the study show a degree of flexibility in their selection of KPIs suggests that subjective analysis still plays a critical role in the coaches' analysis of performance. Furthermore, it shows

that coaching is a skill and in order to understand and represent the nature of events during live performances, there has to be an element of flexibility in the way coaches analyse performance. In addition, most of the coaches felt extremely confident that the selection of their KPIs contributed to their team's success. This was similar to the results from the study by Wright *et al*. (2013). A similar trend was observed at all levels, with provincial coaches (60.0%) being slightly more confident in their selection of KPIs compared to school coaches (56.0%), while the latter were slightly more confident compared to university coaches (53.0%). This high level of confidence in the selection of KPIs could be due to the use of longitudinal data analysis by coaches which they may have acquired through their years of experience in coaching practice. This can be seen as coaches who used PA all the time were on average slightly older than those who did not use PA all the time (41.2 ± 8.57 years vs. 35.7 ± 9.9 years), although this difference was not statistically significant ($p > 0.05$). This could also be due to the fact that coaches who used PA all the time had slightly more coaching experience in years compared to the coaches who did not use PA all the time (12 ± 4.6 years vs.9.4 ± 4.3 years), even though this difference was not statistically significant ($p > 0.05$).

5. VALUE OF PERFORMANCE ANALYSIS

In a previous study, the majority of coaches (89.9%) highlighted that they reviewed their analysis with coaching and management staff before conducting feedback to the players (Wright *et al*., 2012). In the current study, Figure 5.7 shows that the majority of coaches did not have a relationship with a performance analyst, possibly because the majority of coaches carry out their own performance analysis. In the current study, 47.8% of the coaches felt the service that was conducted by the individual who conducted performance analysis was essential, while 34.8% valued it as being very important. This trend was also observed across all respective levels. These results are almost the same as in the study by Wright *et al*. (2013) where 46.0% of the coaches found the service provided by the analyst to be essential, while 34.0% valued it as being very important.

6. CONCLUSION

A major finding in this study was that the majority of coaches involved in high level coaching in South Africa valued performance analysis and used it consistently to inform their coaching. Furthermore, the highest level of coaches who participated in this study, namely the provincial coaches, had most access to PA, used it more often and indicated that PA guided them consistently in their coaching.

Most of the coaches, especially at provincial level, regarded the use of PA to introduce changes to their game tactics as essential. An important discovery was that most of the coaches relied on their coaching philosophy to select KPIs, and in most cases the KPIs changed from game to game. Only provincial coaches indicated that their KPIs remained consistent from game to game.

The findings of this study provide insight into how performance analysis is currently being used by South African rugby coaches, relating to what aspects contribute to their coaching practice.

The study was novel to rugby as well as the coaching levels involved, therefore coaches should learn more about the benefits provided by PA as well as its importance. Furthermore, within the WR coaching levels, coaches only encounter the use of PA in level 3. The current study has shown that the majority of coaches have an WR level 2 coaching qualification, but carry out their own PA. Perhaps, the use of PA should already be introduced into the WR level 2. This will allow the majority of coaches who do not have access to gain a better understanding about the use of PA in rugby.

7. RECOMMENDATIONS

Due to PA being common at all levels of rugby within South Africa, it may be suggested that performance analysis be included earlier into the WR coaching courses to better prepare the coaches.

8. LIMITATIONS

Although the response rate in this study was better than other similar studies, it remains a limitation that not all the coaches who were intended to be included in the study, completed the questionnaire. This limits the generalizability of the results within South African rugby.

More information and insight could have been obtained from coaches if it was possible to conduct interviews, instead of using a questionnaire. On the one hand the questionnaire must preferably be as short as possible so that coaches were not discouraged by the time and effort it would take to participate. On the other hand, some questions, such as those on the KPIs and how PA informs the coaching process, limited the coaches to one or two answers. Even though coaches had the opportunity to add additional information or explanation, the majority chose not to do so.

9. FUTURE STUDIES

Future studies should explore the major findings from this study further and investigate coaches' responses in more detail in attempt to see how their beliefs and values impact with their individual use of PA. This can be achieved through one on one interviews with the coaches as to find out how coaches' previous experiences, relationships with other coaches and how external influences affect their engagement with PA.

Future studies within South Africa can also add more coaching levels such as coaches at club level competitions, or expand on the number of schools Comparative studies between South Africa and countries from the southern and northern hemisphere where rugby also features as one of the primary sport codes could yield interesting results. For instance, a study on the utilization of PA in the Super Rugby Competition should provide interesting results. Furthermore, the relationship between the utilization of PA and the success of a team should be further explored.

REFERENCES

AGNEW, M.S.B. (2006). Game analysis in rugby union. Unpublished M. (Health Science) thesis. Auckland: Auckland University of Technology.

BENNIE, A. & O'CONNOR, D. (2010). Coaching philosophies: Perceptions from professional cricket, rugby league, rugby union players and coaches in Australia. *International Journal of Sports Science and Coaching*, 5(2): 309- 320.

BISCOMBE, T. & DREWETT, P. (2010). *Rugby: Steps to success*. Champaign, ICC: Human Kinetics.

BOKSMART, (2014). *Boksmart* .Hyperlink [http://boksmart.sarugby.co.za/] 13 July 2014.

BORTOLI, L.; BERTOLLO, M.; MESSINA, G.; CHIAROTTI, R. & ROBAZZA, C. (2010). Augmented feedback of experienced and less experienced volleyball coaches: A preliminary investigation. *Society of Personality Research (Inc.),* 38(4): 453-460.

BLAZE, A.; ATKINSON, G.; HARWOOD, C. & CALE, A. (2004). Prevalence and perceptions of performance analysis in the English Premier Association Football *Performance Analysis of Sport V, Centre for Performance Analysis, University of Wales Institute, Cardiff*, 79-83.

BRACEWELL, P. (2003). Monitoring meaningful rugby ratings. *Journal of Sports Sciences,* 21(8): 611-620.

BUDESCU, E.I. & IACOB, I. (2008). The Human Impact Biomechanics in Rugby Game. *In ICCES: International Conference on Computational and Experimental Engineering and Sciences,* 8(1): 31-40.

CALLEJ, L. (2001). Coaching Styles. Hyperlink [http://www.brianmac.co.uk/styles.htm]. 23 April 2015.

CARLING, C.; WILLIAMS, M.A. & REILLY, T. (2005). *Handbook of soccer match analysis.* London, Routledge.

CARLING, C.; REILLY, T. & WILLIAMS, M.A. (2009). Performance Assessment for Field Sports. *Journal of Sports Science and Medicine*, 8(1): 152.

CARTER, A. & MULLER, R. (2008). A survey of injury knowledge and technical needs of junior rugby union coaches in Townsville (North Queensland). *Journal of Science and Medicine in Sport,* 11(2): 167-173.

Currie Cup Rugby News, Results and Fixtures from Rugby Week and Currie Cup Rugby. (2014). Hyperlink [http://www.rugbyweek.co.za/curriecup/history.asp]. 15 July 2014.

CRISSFIELD, P. (1998), *Analysing your coaching*, *The Start of Your Journey Towards Coaching Excellence*. Leeds: The National Coaching Foundation.

DEUTSCH, M.U.; KEARNEY, G.A. & REHRER, N.J. (2007). Time – motion analysis of professional rugby union players during match-play. *Journal of Sports Sciences,* 25(4): 461-472.

DUFFY, P.; HERTLEY, H.; BALES, J.; CRESPO, M.; DICK, F.; VARDHAN, D. & CURADO, J. (2011). Sport coaching as a 'profession': Challenges and future directions. *International Journal of Coaching Science*, 5(2): 93-123.

DURANDT, J.; LAMBERT, M.; MASIMLA, H. & PARKER, Z. (2011). Rugby-playing history at the national U13 level and subsequent participation at the national U16 and U18 rugby tournaments. *South African Journal of Sports Medicine*, 23(4): 103-105.

DUTHIE, G.; PYNE, D. & HOOPER, S. (2003). Applied physiology and game analysis of rugby union. *Journal of Sport Medicine*, 33(13): 973-991.

FRANCIS, J. & JONES, G. (2014). Elite Rugby Union Players Perceptions of Performance Analysis. *International Journal of Performance Analysis in Sport*, 14(1): 188-207.

FRANKS, I.M. & MILLER, G. (1986). Eyewitness Testimony in Sport. *Journal of Sport Behaviour*, 9(1): 38-45.

FRANKS, M.I. (1993). The effects of Experience on the Detection and Location of Performance Differences in a Gymnastic Technique. *American Alliance of Health, Physical Education, Recreation and Dance* 64(2): 227-231.

FULLER, C.W.; RAFTERY, C.; TARGETT, S.G.R. & MOLLOY, M.G. (2009). Impact of the international rugby board's experimental law variations on the incidence and nature of match injuries in southern hemisphere professional rugby union. *South African Medical Journal,* 99(4): 232-237.

FULLER, C.W., TAYLOR, A.E., BROOKS, J.H.M. & KEMP, S.P.T. (2013), Changes in the stature, body mass and age of English professional rugby players: A 10-year review. Journal of Sports Sciences, 31(7), 795-802.

GABBETT, T.J. (2003). Incidence of injury in semi-professional rugby league players. *British Journal of Sports Medicine*, 37(1): 36-44.

GABBETT, T.J. (2004). Reductions in pre-season training loads reduce training injury rates in rugby league players. *British Journal of Sports Medicine*, 38(6): 743-749.

GREEN AND GOLD RUGBY*, (2012). Changes Between the Professional and Amateur Eras Green and Gold Rugby.* Hyperlink [http://www.greenandgoldrugby.com/changes-in-rugby-between-the-professional-and-amateur-eras/]. 23 July 2014.

GREEN, B.S.; BLAKE, C. & CAULIFIELD, B.M. (2011). A valid field test protocol of linear speed and agility in rugby union. *The Journal of Strength and Conditioning Research*, 25(5): 1256-1262.

GROOM, R.; CUSHION, C. & NELSON, L. (2011). The delivery of video-based performance analysis by England youth soccer coaches: Towards a grounded theory. *The Journal of Applied Sport Psychology,* 23(1): 16-32.

GUARDIAN, (2011). Rugby World Cup 2011: Jonny Wilkinson unfazed by new rugby ball. Hyperlink [http://www.theguardian.com/sport/2011/sep/06/rugby-world-cup-2011-wilkinson]. 13 July 2014.

GUILMETTE, T.; MALIA, L. & MCQUIGGAN, M. (2010). Concussion understanding and management among New England high school football coaches. *Brain Injury,* 21(10): 1039-1047.

HOLSTEIN, D. (2010). College athletes' perceptions of effective coaching behaviors and how perceptions influence performance and team satisfaction. Unpublished Ph.D (Education in Ethical Leadership) dissertation. Bourbonnais: Olivet Nazarene University.

HUGHES, M.D. & BARTLETT, R.M. (2002). The use of performance indicators in performance analysis. *Journal of Sport Sciences,* 20(10): 739-754.

HUGHES, M. & BARTLETT, R.M. (2008). Notational Analysis of Sport. In Hughes, M & Franks, I.M. (Ed.), *The use of performance indicators in performance analysis*. London and New York: Routledge.

HUGHES, M. & FRANKS, I.M. (2008). Notational Analysis of Sport. In Hughes, M & Franks, I.M. (Ed.), *Notational Analysis – a review of the literature*. London and New York: Routledge.

HUGHES, M.; HUGHES, M.D.; WILLIAMS, J.; JAMES, N.; VUCKOVIC, G. & LOCKE, D. (2012). Performance indicators in rugby union. *Journal of Human Sport and Exercise,* 7(2): 383-401.

IRB Coaching: The home of Rugby coaching on the web. (2014). Hyperlink [http://www.irbcoaching.com/]. 13 July 2014.

INTERNATIONAL RUGBY BOARD. (2008). *IRB Guide to Experimental Law Variations* Hyperlink [http://www.irb.com/elvs/]. 1 August 2014.

JAMES, N. (2006). Notational analysis in soccer: past, present and future. *International Journal of Performance Analysis in Sport,* 6(2): 67-81.

JAMES, N.; MELLALIEU, S.; JONES, D. & NICHOLAS, M. P. (2005). The development of position-specific performance indicators in professional rugby union. *Journal of Sports Sciences*, 23(1): 63-72.

JENKINS, E.R.; MORGAN, L. & O'DONOGHUE, P. (2007). A case study into the effectiveness of computerised match analysis and motivational videos within the

coaching of a league netball team. *International Journal of Performance Analysis in Sport,* 7(2): 59-80.

JONES, R. & KINGSTON, K. (2013). *An introduction to sports coaching. 1st ed*. New York: Routledge.

JONES, N.M.P.; MELLALIEU, S.D. & JAMES, N. (2004). Team performance indicators as a function of winning and losing in rugby union. *International Journal of Performance Analysis in Sport*, 4(1): 61-71.

KNUDSON, D. (2007). *Fundamentals of biomechanics. 1st ed*. New York: Springer.

KRAAK, J.W.; MALAN, J.D.D. & VAN DEN BERG, H.P. (2011). Analysis of movement patterns and work-to-rest ratios for different panels of South African Rugby Union referees during match refereeing. *International Journal of Performance Analysis in Sport,* 11(2): 344-355.

KRAAK, W.J, & WELMAN, K.E. (2014). Ruck-play as performance indicator during the 2010 Six Nations championship. *International Journal of Sport Science and Coaching*, 9(3): 525-537.

LAIRD, P. & WATERS, L. (2008). Eyewitness recollection of sport coaches. *International Journal of Performance Analysis in Sport*, 8(1): 76-84.

LEE, M. (2011). The use of video feedback as a performance analysis coaching tool in amateur level ice hockey. Unpublished undergraduate (Sports and Leisure Management) thesis. Helsinki: Haaga-Helia University of Applied Sciences.

LIEBERMANN, D.; KATZ, L.; HUGHES, M.; BARTLETT, R.; McCLEMENTS, J. & FRANKS, I. (2002). Advances in the application of information technology to sport performance. *Journal of Sports Sciences*, 20(10): 755-769.

MARTENS, R. (2012). *Successful coaching. 4th ed. Champaign,* IL: Human Kinetics.

MELLALIEU, S.; TREWARTHA, G. & STOKES, K. (2008). Science and rugby union. *Journal of Sports Science,* 26(8): 791-794.

MITCHELL, K. (2003). England player ratings, *The Guardian.* Hyperlink [http://www.theguardian.com/sport/blog/2013/oct/28/vault-rugby-world-cup-2003-england-victory]. 9 June 2015.

O'DONOGHUE, P. (2001). A notational analysis of elite tennis strategy. *Journal of Sport Sciences,* 19(2): 107-115.

O'DONOGHUE, P. (2006). The use of feedback videos in sport. *International Journal of Performance Analysis,* 6(2): 1-14.

O'DONOGHUE, P. (2010). *Research methods for sports performance analysis. 1st ed. Milton Park, Abingdon*. Oxon: Routledge.

ORTEGA, E.; VILLAREJO, D. & PALAO, J.M. (2009). Differences in game statistics between winning and losing rugby teams in the Six Nations Tournament. *Journal of Sports Science and Medicine,* 8(1): 523-527.

OWEN, D. & WEATHERSTON, C. (2002). Professionalization of New Zealand Rugby Union: historical background, structural changes and competitive balance. Department of Economics, University of Otago.

PARSONS, A. & HUGHES, M. (2001). Performance profiles of male rugby union players. In Hughes, M & Franks, I.(Ed.), *Proceedings of the computer science and sport III and performance analysis of sport V conference*, UWIC, Cardiff, Wales.

PERRY, M. (2013). Coaching Behaviors' Effects On Athletes' Anxiety. Unpublished undergraduate (Arts) thesis. Ohio: College of Wooster.

RONAYNE, L. (2004). Effects of coaching behaviors on team dynamics: How coaching behaviors influence team cohesion and collective efficacy over the course of a season. Unpublished M. (Physical Education, Health, and Sport Studies) thesis. Ohio: Miami University.

SIEBRITS, K. & FOURIE, J. (2009). An application of attractiveness measures to evaluate the optimal structure of Currie Cup rugby. *South African Journal for Research in Sport, Physical Education and Recreation*, 31(1): 95-13.

SMART, D.J. (2011). Physical profiling of rugby union players: Implications for talent development. Unpublished Ph.D (Philosophy) dissertation. Auckland: Auckland University of Technology.

SMIT, R.F. (2011). Physiological demands of rugby union matches and practice sessions. Unpublished M. (Sport Sciences) thesis. Pretoria: University: University of Pretoria.

SOCCERMETRICS RESEARCH. Soccermetrics Interview #3: Gavin Fleig (Part I). Hyperlink [http://www.soccermetrics.net/soccermetrics-interviews/soccermetrics-interview-3-part-1-gavin-fleig]. 20 June 2012.

SOUTH AFRICAN RUGBY UNION. (2012). *Club rugby in South Africa receives a major boost.* Hyperlink [http://www.sarugby.net/article.aspx?category=sarugby/clubchampionships&id=1590281]. 1 August 2014.

SPORT 24. (2015). Currie Cup Results. *Sport 24.* Hyperlink [http://www.sport24.co.za/Rugby/CurrieCup/Results]. 24 April 2015.

SUPERSPORT OFFICIAL WEBSITE, (2015). *All set for Cell C Community Cup kick-off.* Hyperlink [http://mobi.supersport.com/rugby/sa-ugby/news/150210/All_set_for_Cell_C_Community_Cup_kickoff]. 17 June 2015.

THE IOC. (2015). Olympic Solidarity Commission. Hyperlink [http://www.olympic.org/olympic-solidarity-commission]. 24 April 2015.

THE SPORT JOURNAL, (2008). Music in Sport and Exercise: An Update on Research and Application. Hyperlink [http://thesportjournal.org/article/music-sport-and-exercise-update-research-and-application/]. 13 July 2014.

TRUEMAN, N. (2014). Rugby Football History. Hyperlink [http://www.rugbyfootballhistory.com/ball.htm]. 13 July 2014.

UNIVERSITY SPORTS SOUTH AFRICA. (2014). Hyperlink [http://www.ussa.org.za/]. 23 July 2014.

VAHED, M.Y. (2014). The effect of the law changes on the physical profile of the South African Currie Cup rugby tournament during 2007 and 2013. Unpublished M (Sport Science) thesis. Stellenbosch: University: University of Stellenbosch.

VAZ, L.; CARRERAS, D. & KRAAK, W. (2012). Analysis of the effect of alternating home and away field advantage during the Six Nations Rugby Championship. *International Journal of Performance Analysis in Sport,* 12(1): 593-607.

VAZ, L.; VAN ROOYEN, M. & SAMPAIO, J. (2010). Rugby game-related statistics that discriminate between winning and losing teams in IRB and Super Twelve close games. *Journal of Sport Science and Medicine,* 9(1): 51-55.

VAN DER BERG, W. (2010). *Great moments in Currie Cup history. 1st ed*. Johannesburg: Penguin Books.

VAN DEN BERG, P. & MALAN, D.D.J. (2012). The effect of Experimental Law Variations on the Super 14 Rugby Union Tournaments. *African Journal of Physical, Health Education, Recreation and Dance,* 18(3): 476-486.

VAN DER WESTHUYZEN, J. (2014). Unpacking the Bok exodus. Hyperlink [http://www.iol.co.za/sport/rugby/springboks/unpacking-the-bok-exodus-1.1689502#.VXcYfSs0VcY]. 9 June 2015.

VARSITY CUP (2014). *About | Varsity Cup*. (2014). Hyperlink [http://varsitycup.co.za/about/]. 23 July 2014.

VIVIAN, R.; MULLEN, R. & Hughes, M. (2001). Performance profiles at league, european cup and international levels of male rugby union players, with specific reference to flankers, no 8 and no 9. Paper presented at the Pass.com: Fifth World Congress of Performance Analysis of Sport, Cardiff, UK.

WILLIAMS, M.A. (2009). Performance Assessment for Field Sports. *Journal of Sports Science and Medicine*, 8(1): 152.

WRIGHT, C.; ATKINS, S. & JONES, B. (2012). An analysis of elite coaches' engagement with performance analysis services (match, notational analysis and technique analysis). *International Journal of Performance Analysis in Sport,* 12(1): 436-451.

WRIGHT, C.; ATKINS, S.; JONES, B. & TODD, J. (2013). The role of performance analysts within the coaching process: Performance Analysts Survey 'The role of performance analysts in elite football club settings.' *International Journal of Performance Analysis in Sport,* 13(1): 240-261.